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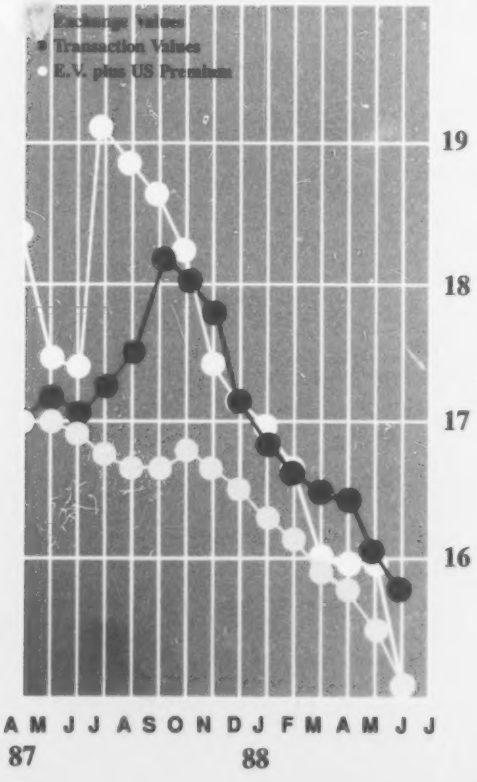

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Three Park Central, Suite 900 | 1515 Arapahoe Street | Denver, Colorado 80202 USA
Telephone: (303) 893-4015 | Telecopy: (303) 825-4821 | Telex: 450202 (NUEXCO DVR)

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MONTHLY REPORT ON THE NUCLEAR FUEL MARKET

July 1988 No. 239

R. GENE CLARK, *EDITOR* FRANCE A. HEAD, *ASSOCIATE EDITOR*

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MARKET VALUES SUMMARY

June 30, 1988	Market Values	Active Supply[1] (thousands)	Active Demand[1] (thousands)
EXCHANGE VALUE[1]	**$15.10**/lb U_3O_8	7,225[2]	1,325[2]
US Premium[7]	**- 0 -**		
UF_6 VALUE[2]	**$44.00**/kg U as UF_6	7,225[2]	1,325[2]
US Premium	**- 0 -**		
CONVERSION VALUE[3]	**$1.80**/lb U as UF_6	0	1050
SWU VALUE[4]			
0.3 tails assay:	**$68**/SWU	265	30
LOAN RATE[5]	**3.5%**/annum	5,600	0

	$/lb. U_3O_8	Millions of Pounds	Number of Transactions	Number of Months
TRANSACTION VALUE[6]	**15.80**	**2.4**	**15**	**4**

[1]Supply and demand tables in the *Current Market Data* section of this Report detail the numbers for each category.
[2]For either uranium concentrates or uranium hexafluoride.

DEFINITIONS

1. The **Exchange Value** is Nuexco's judgment of the price at which transactions for significant quantities of natural uranium concentrates could be concluded as of the date indicated.
2. The **UF_6 Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of natural uranium hexafluoride could be concluded as of the date indicated.
3. The **Conversion Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of conversion services could be concluded in the secondary market as of the date indicated.
4. The **SWU Value** is Nuexco's judgment of the price at which spot and near-term transactions for significant quantities of enrichment services could be concluded as of the date indicated.
5. The **Loan Rate** is Nuexco's judgment of the annual interest rate at which uranium loans could be concluded as of the date indicated.
6. The **Transaction Value** is a weighted average price of recent natural uranium sales transactions. The calculation is based on prices paid in:
   a. Transactions closed within the previous three month period for which delivery is scheduled within one year of the transaction date;
   b. At least ten transactions;
   c. Transactions involving a sum total of at least 2 million pounds U_3O_8 equivalent.

The sample time is extended as necessary to include these minima. Other currencies are converted to US dollars using conversion rates in effect on or near the transaction date.

7. The **US Premium** is Nuexco's judgment of the incremental price (relative to the Exchange Value or UF_6 Value, as applicable) at which transactions for significant quantities of natural uranium could be concluded as of the date indicated, if the buyer will accept only US-origin.

DERIVATIONS AND COMMENTS

1. All Market Values are based on:
   a. Data from recently completed transactions.
   b. Data from pending transactions.
   c. Firm bids to buy or borrow, and firm offers to sell or lend.
   d. Prices purchasers or rates borrowers have expressed a willingness to pay, but for which Nuexco is not aware of firm bids to buy or borrow, and prices sellers or rates lenders have expressed a willingness to accept, but for which Nuexco is not aware of firm offers to sell or lend.
2. Prices associated with deliveries under old or renegotiated contracts or other than arm's-length transactions are not included in the determination of these Market Values.
3. In the determination of prices, Nuexco does not consider transportation charges other than those customarily provided by suppliers .
4. The prices of services or materials delivered under long-term contracts with primary suppliers are not considered in the determination of the listed values.
5. For the SWU Value, Nuexco converts SWU prices at varying tails and product assays to equivalent SWU prices at a tails assay of 0.30 weight percent U^{235} and a product assay of 3.0 weight-percent U^{235}, assuming feed costs corresponding to the Nuexco Exchange and Conversion Values determined as of the same date.
6. In calculating the Transaction Value, Nuexco does not account for the price of uranium delivered in connection with contracts which call for "market price" mechanisms. This exclusion applies particularly to contracts in which delivery prices are expressed as a function of future Exchange Values or any other indeterminate variable. Also excluded from the calculation are any other transactions in which the delivery price is defined in such a way that it cannot currently be determined.

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NATURAL URANIUM AND SECONDARY MARKET CONVERSION

(All data as of June 30, 1988)

Activity increased in the U_3O_8 market this month, as transactions involving over eight million pounds U_3O_8 for both near and long-term delivery occurred. The UF_6 market was dormant, although several utilities are evaluating offers. The secondary conversion market was also quiet, with only one transaction taking place this month. Non-DOE SWU dominated the secondary enrichment market, and four sales involving approximately 400,000 SWU are reported.

The **Exchange Value** is **$15.10** per pound U_3O_8, down $0.30 from last month. Eight U_3O_8 transactions are reported this month involving approximately 8.4 million pounds U_3O_8. Four met the conditions for inclusion in the Transaction Value calculation, and four were longer-term contracts. The four long-term sales, totalling more than seven million pounds U_3O_8, all involved US-origin material. The four spot market transactions were split between both US and non-US material. The non-US U_3O_8 changed hands at prices below those at which the US material sold, although no difference was present at month end. Although market volume was up, downward pressure on the Exchange Value continued.

The major influence on the U_3O_8 market this month was the long-awaited Supreme Court decision on the US Producers vs. DOE lawsuit, which was announced June 16 (see article on page 13). The Court reversed the judgment of the Court of Appeals and remanded the case to the lower courts for further fact finding. Although the US Producers have announced plans to seek a District Court hearing to determine whether enrichment restrictions can assure the industry's viability, most market participants do not foresee any early resolution of the court-related issues and are thus transacting business again.

In addition, the prospects for attaching the proposed settlement between the US Producers, the Reagan Administration, nuclear utilities and Congress to the Free Trade Agreement (FTA) implementing legislation, have now waned due to opposition by several influential House members. Whether these issues will be resolved at any time is uncertain, although immediate relief appears unlikely.

The **US Premium** for **U_3O_8** fell to **zero** this month, in response to the Supreme Court announcement which effectively signals that no enrichment restrictions will be imposed on non-US uranium in the near future, if at all. Most utilities which had previously indicated a preference for US material are now willing to purchase nearly any origin and are evaluating purchasing opportunities primarily from an economic standpoint. Suppliers of US origin material, many of which had been holding material in hopes of a favorable Supreme Court decision, now have become aggressive sellers. As a result, there appears to be little incentive or need to pay a premium for US material at this time, and several current transactions may be filled by US-origin material where the buyer has not restricted the origin.

* * *

Active supply of natural uranium (concentrates and UF_6) for spot delivery totals **7,225,000 pounds** U_3O_8 equivalent, an increase of 235,000 pounds from last month. **Active demand** for natural uranium also showed upward movement, increasing by 415,000 pounds to **1,325,000**. The near-term supply-demand ratio is 5.5, compared to last month's ratio of 7.8.

* * *

The **Transaction Value** is **$15.80** per pound U_3O_8, down $0.30 since last month. The calculation extends over a four-month period and includes 15 transactions involving 2.4 million pounds U_3O_8 equivalent.

* * *

The **UF_6 Value** is **$44.00** per kilogram U as UF_6, and has decreased by $0.75 from last month. No UF_6 transactions are reported during June, although two utilities were close to concluding purchases at the end of the month. While supply of UF_6 is less abundant than the current supply of U_3O_8, the presence of aggressive sellers has effectively weakened the UF_6 market.

The **US Premium** for **UF_6** decreased to **zero**, due to the same reasons mentioned above for the US Premium for U_3O_8.

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The **Loan Rate** is again unchanged at **3.5 percent** per annum, and no loan transactions transpired during June.

* * *

The **Conversion Value** remained at **$1.80** as the conversion services market was quiet. Only one transaction was reported involving a US utility. Two utilities, however, are expected to evaluate within the next few month secondary market conversion offers for the 1989 delivery period.

* * *

ENRICHMENT SERVICES AND SWU

There was no change in the SWU Value of $68.00, but activity was more pronounced in this sector of the nuclear fuel market than during the previous month. Four transactions are reported involving almost 400,000 SWU of non-DOE origin. One of these sales was concluded in late 1987, although delivery was scheduled for this month. In addition, at the end of June a US utility was finalizing a purchase of secondary market DOE-origin SWU from DOE. While a few US utilities may consider long-term SWU offers during 1988, the spot market for SWU has shifted to the 1989 time frame, both for contracting as well as for delivery. Thus, the secondary SWU market is expected to be relatively quiet for the next several months.

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CURRENT MARKET DATA

EXCHANGE VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	per lb. U_3O_8 as Concentrates			per kg U as Concentrates		
	This Month (June 30, 1988)	Last Month (May 31 1988)	12 Months Ago (June 30. 1987)	This Month (June 30, 1988)	Last Month (May 31, 1988)	12 Months Ago (June 30, 1987)
Australia (dollar)	19.22	19.07	23.43	49.96	49.58	60.92
Belgium (comm. franc)	575.68	550.00	640.15	1,497	1,430	1,664
Canada (dollar)	18.34	19.07	22.53	47.69	49.59	58.58
EEC (ecu)	13.26	12.65	14.91	34.46	32.89	38.77
Finland (markka)	65.40	62.30	75.21	170.02	161.96	195.53
France (franc)	92.75	88.91	103.11	241.13	231.16	268.07
FRG (mark)	27.51	26.44	30.90	71.53	68.74	80.34
Italy (lira)	20,416	19,605	22,410	53,078	50,970	58,263
Japan (yen)	2,007	1,904	2,478	5,218	4,949	6,443
Netherlands (guilder)	31.05	29.58	34.82	80.72	76.90	90.53
South Africa (rand)	35.11	34.34	34.53	91.27	89.27	89.76
Spain (peseta)	1,827	1,742	2,415	4,749	4,529	6,278
Sweden (krona)	94.55	91.45	107.92	245.81	237.75	280.56
Switzerland (franc)	22.80	22.10	25.68	59.28	57.45	66.76
UK (pound)	8.81	8.29	10.56	22.90	21.56	27.45
US (dollar)	15.10	15.40	16.90	39.26	40.04	43.94

TRANSACTION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	per lb. U_3O_8 as Concentrates			per kg U as Concentrates		
	This Month (June 30, 1988)	Last Month (May 31, 1988)	12 Months Ago (June 30, 1987)	This Month (June 30, 1988)	Last Month (May 31, 1988)	12 Months Ago (June 30, 1987)
Australia (dollar)	20.11	19.94	23.71	52.27	51.83	61.64
Belgium (comm. franc)	602.36	575.00	647.73	1,566	1,495	1,684
Canada (dollar)	19.19	19.94	22.80	49.90	51.84	59.27
EEC (ecu)	13.87	13.23	15.09	36.06	34.39	39.23
Finland (markka)	68.43	65.13	76.10	177.90	169.32	197.85
France (franc)	97.05	92.96	104.33	252.31	241.66	271.24
FRG (mark)	28.79	27.64	31.27	74.85	71.87	81.29
Italy (lira)	21,363	20,497	22,676	55,539	53,286	58,953
Japan (yen)	2,100	1,990	2,508	5,459	5,174	6,519
Netherlands (guilder)	32.49	30.93	35.24	84.47	80.40	91.61
South Africa (rand)	36.74	35.90	34.93	95.50	93.33	90.82
Spain (peseta)	1,911	1,821	2,444	4,969	4,735	6,353
Sweden (krona)	98.94	95.61	109.20	257.21	248.55	283.88
Switzerland (franc)	23.86	23.10	25.98	62.03	60.06	67.55
UK (pound)	9.22	8.67	10.68	23.97	22.54	27.78
US (dollar)	15.80	16.10	17.10	41.08	41.86	44.46

[1]Calculated using currency exchange rates published in the *Wall Street Journal* on the last working day of the month.

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CONVERSION VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

Country (currency)	per lb U as UF_6			per kg U as UF_6		
	This Month (June 30, 1988)	Last Month (May 31, 1988)	12 Months Ago (June 30, 1987)	This Month (June 30, 1988)	Last Month (May 31, 1988)	12 Months Ago (June 30, 1987)
Australia (dollar)	2.29	2.23	2.50	5.05	4.91	5.50
Belgium (comm. franc)	68.62	64.29	68.18	151.29	141.73	150.31
Canada (dollar)	2.19	2.23	2.40	4.82	4.91	5.29
EEC (ecu)	1.58	1.48	1.59	3.48	3.26	3.50
Finland (markka)	7.80	7.28	8.01	17.19	16.05	17.66
France (franc)	11.06	10.39	10.98	24.38	22.91	24.21
FRG (mark)	3.28	3.09	3.29	7.23	6.81	7.26
Italy (lira)	2,434	2,292	2,387	5,365	5,052	5,262
Japan (yen)	239.23	222.50	263.97	527.42	490.52	581.95
Netherlands (guilder)	3.70	3.46	3.71	8.16	7.62	8.18
South Africa (rand)	4.19	4.01	3.68	9.23	8.85	8.11
Spain (peseta)	217.73	203.62	257.22	480.02	448.90	567.06
Sweden (krona)	11.27	10.69	11.49	24.85	23.56	25.34
Switzerland (franc)	2.72	2.58	2.74	5.99	5.69	6.03
UK (pound)	1.05	.97	1.12	2.32	2.14	2.48
US (dollar)	1.80	1.80	1.80	3.97	3.97	3.97

SWU VALUE AND UF_6 VALUE EXPRESSED IN SELECTED PRODUCER & CONSUMER CURRENCIES[1]

	SWU Value at 0.30% Tails Assay This Month (June 30, 1988)	SWU Value at 0.30% Tails Assay Last Month (May 31, 1988)	UF_6 Value per kg U as UF_6 This Month (June 30, 1988)	UF_6 Value per kg U asUF_6 Last Month (May 31, 1987)
Australia (dollar)	86.54	84.21	55.99	55.41
Belgium (comm. franc)	2,592	2,429	1,677	1,598
Canada (dollar)	82.60	84.22	53.44	55.42
EEC (ecu)	59.69	55.87	38.62	36.76
Finland (markka)	294.50	275.08	190.55	181.02
France (franc)	417.69	392.61	270.27	258.37
FRG (mark)	123.91	116.76	80.17	76.83
Italy (lira)	91,942	86,569	59,492	56,970
Japan (yen)	9,038	8,405	5,848	5,532
Netherlands (guilder)	139.83	130.62	90.47	85.95
South Africa (rand)	158.10	151.62	102.30	99.77
Spain (peseta)	8,225	7,692	5,322	5,062
Sweden (krona)	425.80	403.80	275.51	265.73
Switzerland (franc)	102.69	97.57	66.44	64.21
UK (pound)	39.67	36.62	25.67	24.10
US (dollar)	68.00	68.00	44.00	44.75

[1]Calculated using currency exchange rates published in the *Wall Street Journal* on the last working day of the month.

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CURRENT MARKET DATA

RECENT TRANSACTIONS[1]

URANIUM SALES

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U_3O_8 equivalent)	Approximate Price Range as Percent of Current Exchange or UF_6 Value[2]	Seller	Buyer	Remarks
4301	1988-95	3,001-5,000	See Remarks	Producer	Utility	US Origin, Base Price Escalated
4317	1988	301-600	R[3]	Producer	Utility	US Origin
4323	1988-91	101-300	See Remarks	Intermediary	R[3]	US Origin, Base Price Escalated
4326	1990-95	1,501-3,000	See Remarks	Producer	Utility	US Origin, Price Related To Market
4327	1988	101-300	98-102	Utility	Intermediary	
4329	1988	less than 50	103-107	Producer	Intermediary	US-Origin
4332	1988	50-100	98-102	Producer	Intermediary	
4333	1989-92	1,501-3,000	See Remarks	Producer	Utility	Price Related to Market

[1] Transactions listed are not limited to those in which Nuexco was involved, but also include others of which Nuexco is aware.
[2] Where US-origin material is involved, the range is based on the Exchange Value (or UF_6 Value) *plus* the premium (relative to the Exchange Value or UF_6 Value). The range reflects five percentage points (inclusive) per grouping, centered about the middle of the range.
[3] The notation R means that Nuexco either does not know, or that Nuexco has restricted that information to protect client or source confidentiality.

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CONVERSION SERVICES
SECONDARY MARKET SALES

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U equivalent)	Approximate Price Range as Percent of Current C.V.	Seller	Buyer	Remarks
4322	1988	301-600	R[3]	Intermediary	Utility	

ENRICHMENT SERVICES
SECONDARY MARKET SALES

Nuexco Transaction Number	Delivery Period	Approximate Quantity[4] (thousands of SWU)	Approximate Price Range as Percent of Current SWU Value[5]	Seller	Buyer	SWU Origin	Remarks
4311	1988	50-100	93-97	Intermediary	Utility	Non-DOE	
4313	1988	101-300	98-102	Intermediary	Utility	Non-DOE	
4321	1988	101-300	R[3]	Intermediary	Utility	Eurodif	
4330	1988	50-100	93-97	Intermediary	Utility	Non-DOE	

LOAN TRANSACTIONS

Nuexco Transaction Number	Delivery Period	Approximate Quantity (thousands of pounds, U_3O_8 equivalent)	Approximate Price Range as Percent of Current Loan Rate)	Lender	Borrower	Remarks

No loan transactions are reported this month.

[1] Transactions listed are not limited to those in which Nuexco was involved, but also include others of which Nuexco is aware.
[2] Where US-origin material is involved, the range is based on the Exchange Value (or UF_6 Value) *plus* the premium (relative to the Exchange Value or UF_6 Value). The range reflects five percentage points (inclusive) per grouping, centered about the middle of the range.
[3] The notation R means that Nuexco either does not know, or that Nuexco has restricted that information to protect client or source confidentiality.
[4] If tails assay is unknown or unspecified, Nuexco's calculation of SWU quantity assumes 0.30 w/o tails assay.
[5] Prices are usually normalized to 0.30% tails assay. Refers to SWU Vaiue that corresponds to SWUs included in transaction. When prices and SWU values are expressed as discounts from a reference price (e.g., X dollars less than DOE's USEC base price at time of delivery), the percentage price range is based on the discounted prices, not on the reference price.

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CURRENT MARKET DATA

URANIUM SUPPLY
(June 30, 1988)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Available for Sale			
ACTIVE			
87-1002	270	—	
87-1023	500	500 per year	1988-90
87-1061	1,000	700 per year	1988-91
87-1123	1,000	1,000 per year	
87-1141	500	200 per year	1989-92
87-1161	1,000	1,000 per year	UF_6
88-1000A*	350	—	1988
88-1000B*	320	—	1988, UF_6
88-1001	200	200 per year	1988-91
88-1026	250	—	1988
88-1033A	130	—	1988, UF_{6e}
88-1036	100	—	1988
88-1064	400	400 per year	1988-90
88-1078*	1,200	—	1988
87-1001	—	500 per year	1989 on
87-1005	—	250 per year	1988-95
88-1096A	—	290	1990, UF_{6e}
Total	**7,225**		
INACTIVE			
87-1019	1,000	1,000 per year	1988-91
87-1053*	100	500 per year	1989 on
87-1159	60	—	
88-1086*	75	—	1988
87-1130*	—	580	1989
Total:	**1,235**		

*New or revised since last month.
[1] Measured from the date of this Report.
[2] For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.
Projects removed since last month: 88-1041.

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URANIUM DEMAND
(June 30, 1988)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Inquiries to Purchase:			
ACTIVE			
88-1035A	40	—	1988, UF_6e
88-1060	300	—	1988, U_3O_8/UF_6
87-1069	50	—	1988
88-1084	500	—	1988
88-1094*	35	—	1988
88-1100*	50	—	1988
88-1102*	350	—	1989
87-1134	—	260	1989
87-1172	—	500 per year	1990 on
88-1044	—	2,400	1991-95
88-1056	—	500 per year	1989-93, U_3O_8 or UF_6
88-1062	—	200 per year	1990-on
88-1089*	—	1,200 per year	1990-95
Total:	**1,325**		
INACTIVE			
87-1154A	80	—	1988, UF_6e
88-1014*	100	—	1988
88-1083*	800	—	1988
87-1163	—	160	1989-93
Total:	**980**		

*New or revised since last month.
[1] Measured from the date of this Report.
[2] For delivery within one year. This category excludes material deliverable within one year under other than spot or near-term contracts.
Projects removed since last month: 87-1013, 87-1021, 87-1166, 88-1075A, 88-1080.

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CURRENT MARKET DATA

LOAN SUPPLY AND DEMAND
(June 30, 1988)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U_3O_8) Within 1 Year	Beyond 1 Year	Remarks
Available for Loan:			
ACTIVE			
87-1012	1,000	—	
87-1157	4,000	—	
88-1057	600	—	
Total:	**5,600**		
INACTIVE			
87-1031	1,000	—	
87-1033	1,000	—	
Total:	**2,000**		
Available to Borrow:			
No inquiries to borrow are reported.			

*New or revised since last month.
[1] Measured from the date of this Report.
Projects removed since last month: 87-1071.

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CONVERSION SUPPLY AND DEMAND
(June 30, 1988)

Nuexco Project Number	Delivery Period[1] (Thousands of Pounds U as UF_6) Within 3 Years	Beyond 3 Years	Remarks
Available for Sale			
ACTIVE			
No active supply reported this month			
INACTIVE			
87-1008	770	475	1988
Total:	**770**		
Inquiries to Purchase			
ACTIVE			
88-1034*	750	—	1990
88-1098*	300	—	1989
Total:	**1050**		
INACTIVE			
88-1021	65	—	
Total:	**65**		

*New or revised since last month.
[1]Measured from the date of this Report.
Projects removed since last month: None.

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CURRENT MARKET DATA

SWU SUPPLY AND DEMAND
(June 30, 1988)

Nuexco Project Number	Delivery Period[1] (Thousands of SWU) Spot or Near-term[2]	Intermediate or Long-term	Remarks
Available for Sale			
ACTIVE			
87-1058	50	—	1988
87-1068	200	—	1988,UF6e
88-1033B	15	—	1988,UF6e
88-1096B*		55	1990, UF6e
Total	**265**		
INACTIVE			
87-1004	55	—	1988
87-1128	360	—	1988
88-1082	25	—	1988
Total:	**440**		
Inquiries to Purchase			
ACTIVE			
88-1035B	20	—	1988, UF6e
88-1085*	10	—	1988
88-1077	—	70	1989-91
Total:	**30**		
INACTIVE			
87-1154B	20	—	1988, UF6e
Total:	**20**		

*New or revised since last month.
[1] Measured from the date of this Report.
[2] For delivery within one year. This category excludes SWU deliverable within one year under other than spot or near-term contracts.
Projects removed since last month: 88-1074, 88-1075B.

AUSTRALIA

Australian Labor Party To Review Uranium Issues

During its biennial National Conference held in early June, the Australian Labor Party (ALP) quite unexpectedly decided to establish a committee to review the Party's uranium policies. This move was unexpected because, despite an aggressive lobbying campaign in the weeks leading up to the Conference, the ALP's right wing still lacked the votes needed to force major changes in the Party's uranium policy, and thus decided against pressing the issue. But when the Center-Left faction suddenly proposed a thorough review of all aspects of uranium policy, the Right was only too happy to agree. Although against the formation of this review committee and any possible liberalization of uranium policy, the left wing's opposition appeared largely perfunctory and lacked its usual, emotional, anti-uranium content.

It seems clear that the economic and common sense arguments advanced by proponents of further uranium development have, at long last, struck a sensitive nerve. Further support for pro-development advocates comes from changes in Canada and the United States. In Canada, the pending merger of the world's two largest, low-cost producers, Saskatchewan Mining Development Corporation (SMDC) and Eldorado Nuclear Ltd., will create a new behemoth, eliminating competition between the two long-time rivals. Buyers are concerned and ready to encourage new sellers, particularly the potential new Australian producers who have the reserves, ore grades, and financial resources to compete head-on with the Canadians.

In the USA, recent legislative, judicial, and political developments make it increasingly unlikely that US utilities will face meaningful restrictions on the use of non-US origin uranium. In turn, US utilities have become more willing to consider non-US sources of supply for the long term, and, with southern African uranium no longer an option for US buyers, Australia becomes the obvious and favored alternate to Canada.

There also appears to be a greater acceptance of uranium mining with Australia in general as evidenced by:

- tacit trade union acceptance that uranium mining is an established industry that is here to stay,
- overt support of the industry by the Northern Territory's traditional landowners who are now realizing the benefits of substantial royalty payments from the existing mines, and who may see an even greater bonanza from their 25 percent equity interest in the Koongarra project, and
- an operational record at Jabiru (Ranger) and Nabarlek that demonstrates that uranium mining does not threaten even the most environmentally sensitive areas when properly conducted.

If new uranium production operations are to be opened in Australia, the most likely candidates are (1) Pancontinental Mining's huge Jabiluka deposit in the Northern Territory, (2) Denison's Koongarra deposit also located in the Northern Territory, (3) Canning Resources' Kintyre deposit in Western Australia, and (4) Western Mining's Yeelirrie deposit, also in Western Australia. While reasonable arguments can be advanced on behalf of each company as to why it should be allowed to proceed ahead of the others, decisions in this area are more likely to be based on political realities than commercial or economic factors.

It does seem clear, however, that barring unexpected external events, the stage has been set for the ALP to alter its uranium policy, most probably by year-end, in the direction of further development and greater freedom for the various mining companies to strike their own commercial deals. Although such changes will likely be cloaked in the most cautious language so as to appear minimal, they now appear inevitable.

* * *

UNITED STATES

Supreme Court Issues Decision on Producers Lawsuit

The Supreme Court issued a unanimous decision in the US Producers vs. DOE lawsuit on June 15, 1988, reversing and remanding the lower courts' ruling that would have required DOE to restrict enrichment of imported uranium when the domestic uranium industry was found to be non-viable. The Court held that:

"Section 161 (v) does not require DOE to restrict enrichment of foreign uranium where such restriction would not achieve the statutory goal of 'assuring the maintenance of a viable domestic uranium industry', for the statute ties the amount of restriction to be imposed to the achievement of that goal. . . . Because we conclude that Congress did not intend to force DOE to impose enrichment restrictions where such restrictions would not achieve the statutory goal they were intended to achieve,

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the judgment of the Court of Appeals is reversed and the case is remanded for further proceedings consistent with this opinion."

The Supreme Court based its ruling on one issue — whether Section 161 (v) required DOE to restrict the enrichment of foreign uranium, regardless of whether any level of restrictions would make the domestic industry viable. In footnote eleven of the decision, the Justices added, "All we have resolved here is that the industry's nonviability does not necessarily trigger an obligation to impose enrichment restrictions. Whether DOE, in fact, has violated Section 161 (v) by failing to impose restrictions is a question to be addressed . . . on remand after an opportunity for presentation of further evidence and further briefing."

Because several issues remain unresolved, neither party emerged as victor in the lawsuit. A few hours after the Supreme Court announced its decision, the US Producers declared they would seek an immediate hearing in the Federal District Court to determine whether restricting the enrichment of foreign uranium will assure a viable domestic industry. In their official statement, the Producers cited the Supreme Court decision as an affirmation of their position. They will, however, now bear the burden of proving how restrictions will help the uranium industry.

It is uncertain how far the Producers will carry this issue, which has already been in litigation for three and a half years. The lower court, following a lengthly factual presentation, may define viability and again place the burden on DOE to establish by rule making, the level of restrictions that will ensure viability under the definition. This process could again result in appeals to higher courts and further prolong the proceedings.

Proposed Settlement

In the meantime, it appears less likely that the proposed settlement between the US Producers, the Reagan Administration, nuclear utilities and Congress, which includes sections of the Uranium Revitalization, Tailings Reclamation and Enrichment Act (S. 2097) and provides for a $750 million government program to purchase domestic uranium, will be attached to the Free Trade Agreement (FTA) implementing legislation. Considerable opposition in the House, primarily from House Ways and Means Committee Chairman Dan Rostenkowski (D-Illinois) and Representative John Dingell (D-Michigan), on procedural grounds has stalled its consideration. The proposed uranium legislation now is expected to be submitted for congressional approval as a stand-alone package, perhaps replacing the Senate Energy Committee's bill, S. 2097. It is questionable if this legislation can be enacted before ratification of the FTA, and if the FTA is entered into, the issues will become moot.

* * *

California Voters Approve Rancho Seco Operation

Residents of Sacramento, California recently voted in favor of continued operation of Sacramento Municipal Utility District's (SMUD) Rancho Seco nuclear plant. Two measures dealing with the plant were presented to voters in early June, and in each case continued operation was favored over shutdown. The 913-MWe Babcock and Wilcox PWR was shut down in late 1985, following an overcooling incident.

The first measure, sponsored by the anti-nuclear group, Sacramentans for Safe Energy (SAFE), called for the immediate shutdown of Rancho Seco as a nuclear plant. It was barely defeated with 50.5 percent of the voters opposing the shutdown. (A "no" vote was required to support nuclear power.) This narrow victory was primarily the result of an extensive and costly public relations campaign which focused on the economic advantages of nuclear energy. The campaign was aided substantially by the unusually dry past winter and spring in California. The resulting sharp reduction of available hydro-power made Rancho Seco's power essential, if SMUD were to avoid purchasing expensive power from other sources.

The second measure, which was sponsored by SMUD, proposed that Rancho Seco be authorized to run for an 18-month trial period, followed by a re-evaluation of its performance. This measure, which passed with 52 percent of the vote, includes a series of performance benchmarks (i.e., a 70 percent annual capacity factor, etc.) which the plant must attain or be subject to shutdown by SMUD's board of directors.

Although winning both votes, nuclear proponents can take little solace from the margins of victory, and it is generally conceded that if Rancho Seco experiences serious new problems on either the conventional or

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nuclear side of the plant, its future as a nuclear generating facility could be in jeopardy.

The situation at SMUD and Rancho Seco has been further complicated by other initiatives. Pacific Gas and Electric Company, in its bid (since rejected) to acquire SMUD, included a provision to close down Rancho Seco. Duke Power Company has expressed interest in operating (but not in owning) Rancho Seco on a fee basis, undoubtedly because of its experience with Babcock & Wilcox PWRs at its Oconee station in South Carolina. Quadrex Corporation, a small, California-based, nuclear plant engineering firm, has indicated interest in assuming management, operation, and ownership roles. Finally, Connecticut-based Consolidated Power Company has proposed converting the plant to a gas-fired station, and is expected to submit a formal proposal in September 1988.

* * *

Agreement Reached in Pacific Gas & Electric Company's Diablo Canyon Rate Case

In an unprecedented move, Pacific Gas and Electric Company (PG&E) has agreed with the State Attorney General and the California Public Utility Commission's Division of Ratepayer Advocates (DRA) to settle the Diablo Canyon rate case by basing the revenues from that nuclear plant on its actual electrical output. The settlement is subject to approval by the Public Utility Commission after public hearings. The DRA had sought to disallow, as imprudently incurred, some $4.4 billion of Diablo Canyon's $5.8 billion total cost. If approved, this settlement will resolve a dispute which began some years ago and might have extended well into the 1990s, exhausting all appeals.

In deciding on this approach, PG&E opted for getting on with business and reducing the uncertainties about when and how the complex legal, financial, regulatory, and political issues would be resolved. In separate but related actions, PG&E's board of directors reduced the quarterly cash dividend by 27 percent (from $0.48 to $0.35 per share) and agreed to take a one-time, $500 million after-tax charge aginst earnings.

The crux of the settlement agreement, however, is the concept of "performance-based pricing." Under this concept, a negotiated price is established for power produced by Diablo Canyon, and PG&E's net inome from the plant is based on how much electricity the plant actually produces, less the plant's operating expenses. The initial price is 7.8 cents per kilowatt-hour beginning July 1, 1988, with provision for annual adjustments thereafter. Obviously, the Diablo Canyon base revenue and PG&E's associated net income will be direct functions of the plant's capacity factor. Based on a price of 7.8 cents per kilowatt-hour, a 65-percent capacity factor would result in annual revenues of about $960 million. A 70-percent factor would equate to revenues of $1.03 billion, and 75 percent would equate to $1.1 billion.

In agreeing to such a settlement to recover and earn a return on its investment in Diablo Canyon (as opposed to the more conventional rate base approach), PG&E has signaled confidence in its ability to operate Diablo Canyon at production levels exceeding the industry average. Of equal importance will be PG&E's incentive and ability to control expenses, particularly manageable items such as operation, maintenance, and nuclear fuel, the costs of which are not passed through to ratepayers under this approach.

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ANALYSIS AND COMMENTARY

WORLD URANIUM CONSUMPTION FORECAST (1988-2000)

This article summarizes the updated uranium consumption forecast for 1988-2000 presented in Nuexco's 1988 Uranium Market Study and Price Forecast.

* * *

The uranium consumption forecast in Nuexco's 1988 Uranium Market Study and Price Forecast covering the years 1988-2000 shows a 0.6 percent increase over last year's forecast. Over this period, uranium consumption is expected to total 1736 million pounds U_3O_8 compared to last year's forecast of 1726 million pounds. Nuexco's incorporation of an optimization of enrichment tails assay in uranium consumption calculations this year, less small reductions in electric generating capacity and average plant capacity factors, account for this modest increase. The source report gives forecasts for various market conditions and possible growth rates. However, in this article only the free market reference growth case is discussed. Table 1 presents a summary of Nuexco's uranium consumption forecast.

Table 1
SUMMARY OF NUEXCO'S WORLD CONSUMPTION FORECAST
Free Market Condition–Reference Growth Case

Consumption (million lbs U_3O_8)	
1988	**108.6**
2000	**151.5**
Between 1988 and 2000:	
• Annual average	**133.5**
• Total over period	**1735.6**
Average Annual Increase Over Study Period	
Million pounds	**3.58**
Percent	**2.82**

Methodology

The term "consumption", as used by Nuexco, means the amount of natural uranium, in the form of ore concentrates, that must be delivered to a conversion plant (where ore concentrates are converted to UF_6) in order to begin preparation of fuel assemblies, on a normal lead time prior to:

1. the commercial operation date (COD) of a given reactor if for an initial core, or
2. the periodic refueling date if for reload fuel.

For an initial core, Nuexco used a 30-month lead time prior to COD, and for reloads, an 18-month lead time prior to refueling. Nuexco considers uranium to be consumed when it enters the chain of fuel preparation operations. Thus, for a reactor starting commercial operation in 1990, the natural uranium for the initial core loading is classified as being consumed in 1987 or 1988. The amount of uranium is expressed as pounds U_3O_8 equivalent.

Principal Variables Affecting Consumption

Some of the main variables that affect the total uranium consumption forecast include:

- nuclear electric generating capacity in operation and annual additions
- nuclear plant design characteristics including the projected operating life, core loading, and thermal efficiency
- nuclear plant operating characteristics such as capacity factor and the cycle length between refuelings
- fuel cycle characteristics including the enrichment tails assay, the recycle of uranium and plutonium, fuel preparation lead times, and processing losses.

Nuclear Electric Generating Capacity

Nuexco's forecast for installed nuclear electric generating capacity incorporates assumptions regarding:

1. the termination of partially constructed but halted reactors, or reactors experiencing difficulty in obtaining final regulatory approval to operate,
2. the completion dates of reactors under construction, and
3. the construction and completion dates of planned and unplanned reactors.

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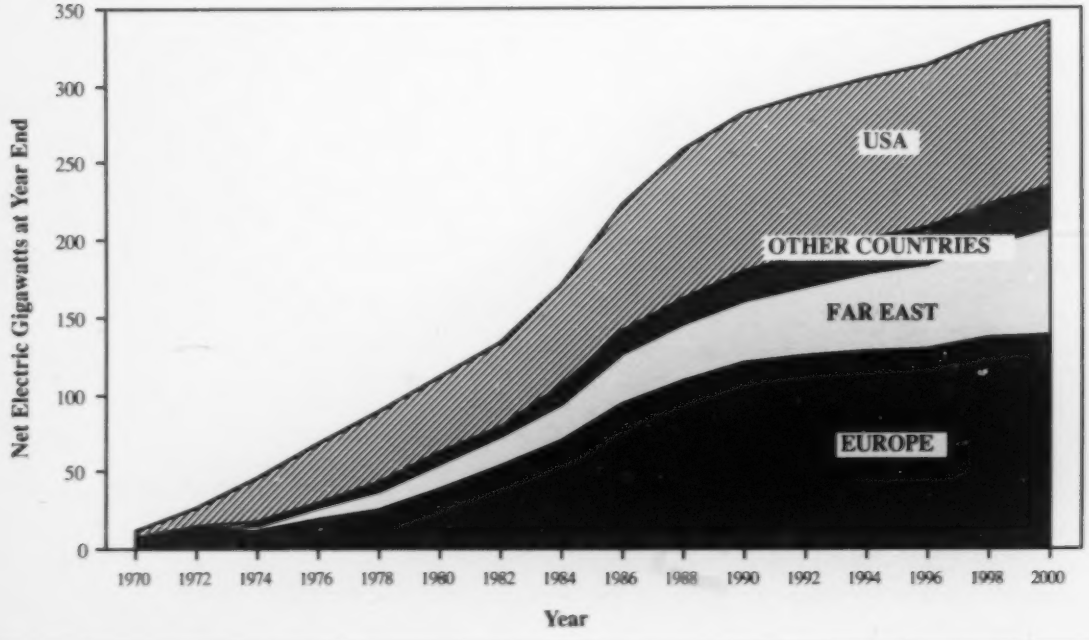
Figure 1
CUMULATIVE INSTALLED NUCLEAR GENERATING CAPACITY BY REGION



Nuexco's forecast shows a world growth from 247.6 net gigawatts electric (GWe net) at the end of 1987 to 340.5 GWe net at the end of 2000. This represents a 37.5 percent installed capacity increase over thirteen years, or an average of 2.5 percent per year. Over the previous thirteen-year period (1975 to 1987), the annual compound capacity growth rate was 13.9 percent. Figure 1 illustrates historical and projected cumulative installed nuclear electric generating capacity by region.

Some of the factors that could potentially affect these projected nuclear generating capacity figures are:

- a higher growth rate in electricity demand than currently anticipated,
- new applications for nuclear power such as process heat,
- greater public acceptance of nuclear energy,
- significant developments in nuclear plant safety and reliability,
- streamlined licensing and construction practices for nuclear plants,
- deregulation of the electric industry, particularly in the USA.

In 1987, Europe had 43 percent of the world's nuclear generating capacity. Public reaction to the Chernobyl accident, however, dampened the future nuclear power plans of several European countries and, consequently, over the period, Europe is projected to increase nuclear capacity at an average rate of only 2.1 percent per year. France will be responsible for half of this growth, contributing approximately 9300 MWe over the next five years. France also produced the largest percentage of its electricity generation from nuclear power than any other country during 1987, as shown in Figure 2.

From a regional perspective, the Far East will experience the most growth in capacity additions at a rate averaging about 4.9 percent per annum.

The major players in the "Other Countries" category include Canada (with four units under construction) and India (six units under construction), although Argentina, Brazil, Mexico and Turkey all have small, slowly

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developing nuclear power programs, the future of which will depend upon available financing. The capacity growth forecast for the Other Countries category is 4.1 percent per year.

Reduced load growth, financial constraints, licensing problems, regulatory changes and weak public support continue to plague the US nuclear industry. The USA held a 60 percent share in total nuclear generating capacity in 1974; its share is now about 36 percent and is decreasing. Between 1988-2000, the USA is expected to add 17,642 MWe of nuclear generating capacity, or about 1.4 percent on an annual average compound growth basis.

Table 2 shows the nuclear electric installed capacity for each region at the beginning and end of the study period.

Table 2
INSTALLED NUCLEAR ELECTRIC CAPACITY BY REGION

Region	1987		2000	
	GWe	%	GWe	%
Europe	106.0	42.8	138.5	40.7
Far East	37.1	15.0	69.0	20.2
Other Countries	16.0	6.5	27.0	7.9
USA	88.5	35.7	106.1	31.2
Total	247.6		340.6	

Figure 2
NUCLEAR PORTION OF TOTAL ELECTRICITY GENERATION BY COUNTRY IN 1987

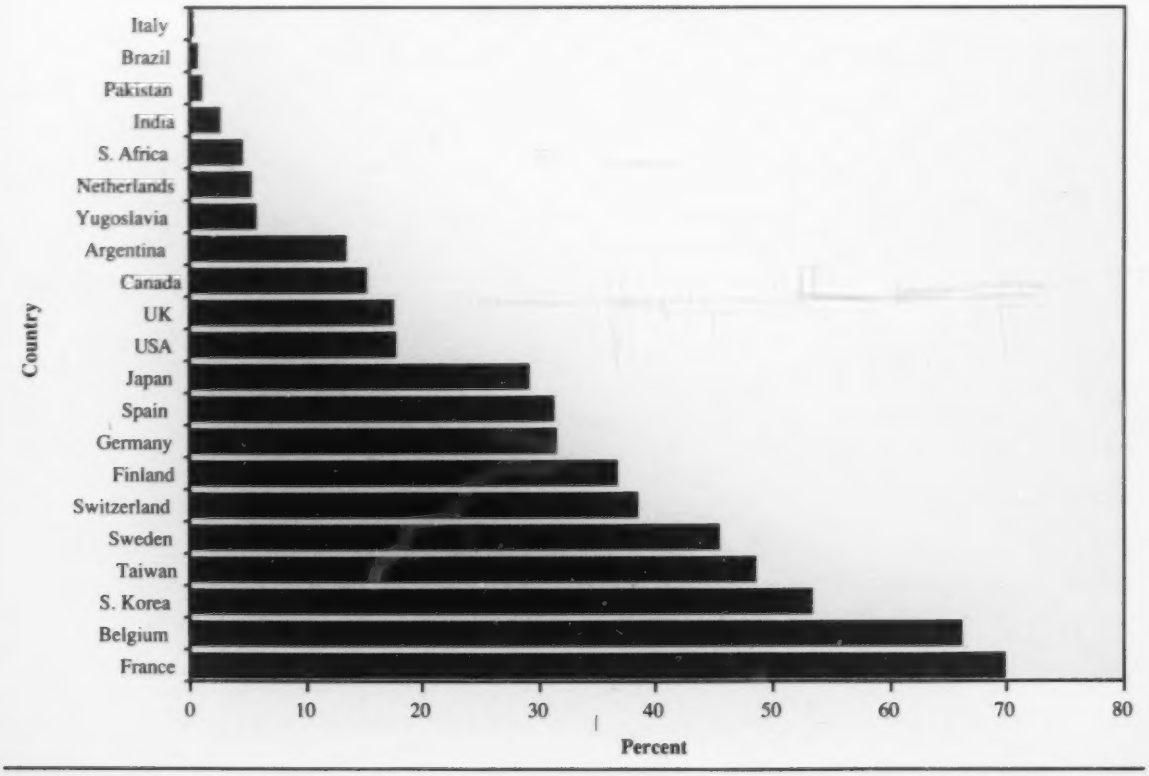

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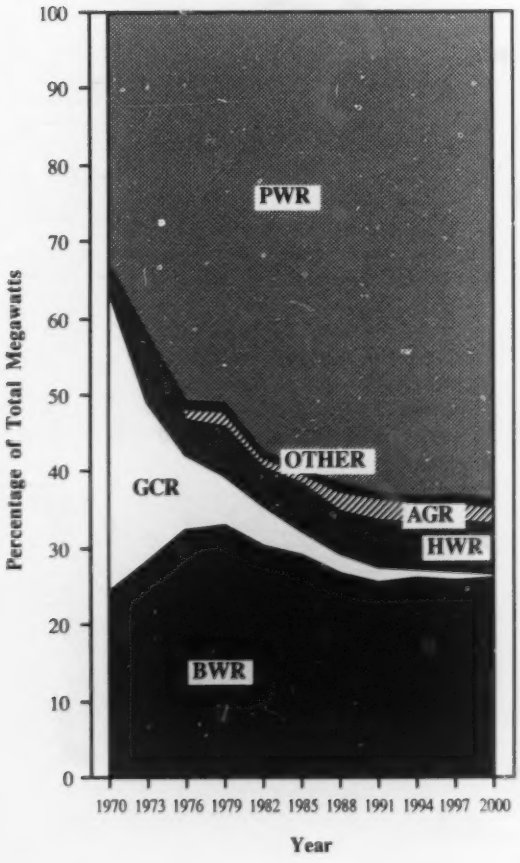
Figure 3
CUMULATIVE INSTALLED NUCLEAR GENERATING CAPACITY
By Reactor Type



In 1970, the gas-cooled reactor (GCR) was the dominant reactor type, although this has been gradually replaced by the pressurized water reactor (PWR). By 2000, the PWR is expected to account for approximately 64 percent of total nuclear electric generating capacity. The reference case forecast of installed nuclear electric generating capacity by reactor type can be seen in Figure 3.

Nuclear Plant Design Characteristics

Nuexco uses a 35-year plant operating life unless a different lifetime is experienced or planned.

Nuexco uses core loadings characteristic of each type of plant and sized to the reactor power rating.

Nuclear Plant Operating Characteristics

The capacity factor of a power plant is the ratio of actual electric production to its 100 percent capability. Known also as "plant factor" or "load factor", the capacity factor assumed to prevail for 1988 is based on the average capacity factor for the years 1985-1987 by reactor type and country. The nuclear power plant capacity factor, on a weighted average world basis, is therefore 66.9 percent in 1988, and assumed to be 71.9 percent in the year 2000.

Figure 4 shows the historical frequency distribution of capacity factor values by region. The Far East showed the highest capacity factor for 1987, with a mean of 77.2 percent. This figure is 23 percent greater than the corresponding figure for the USA. Also, in the Far East the lowest reactor capacity factor in 1987 was about 56 percent, whereas all other regions had at least one reactor with a zero capacity factor. One-third of the worlds reactors experienced a 77 percent or greater capacity factor in 1987.

On a worldwide basis, the weighted average capacity factor used in the consumption forecast is:

Year	Capacity Factor
1988	66.9%
2000	71.9%

In the USA, there is a substantial trend toward longer operating cycles between refuelings which are usually accompanied by greater fuel burnups. Since longer operating cycles theoretically decrease downtime percentage for refuelings, they generally should result in better capacity factors. In addition, they tend to increase uranium consumption slightly per unit of energy production, even in combination with greater fuel burnup.

Fuel Cycle Characteristics

This year's report incorporates an optimization of the enrichment tails assay in the uranium consumption calculations. In each year of the study period, the tails assay selected provides the minimum product cost based

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ANALYSIS AND COMMENTARY

Figure 4
FREQUENCY DISTRIBUTION OF CAPACITY FACTORS BY REGION

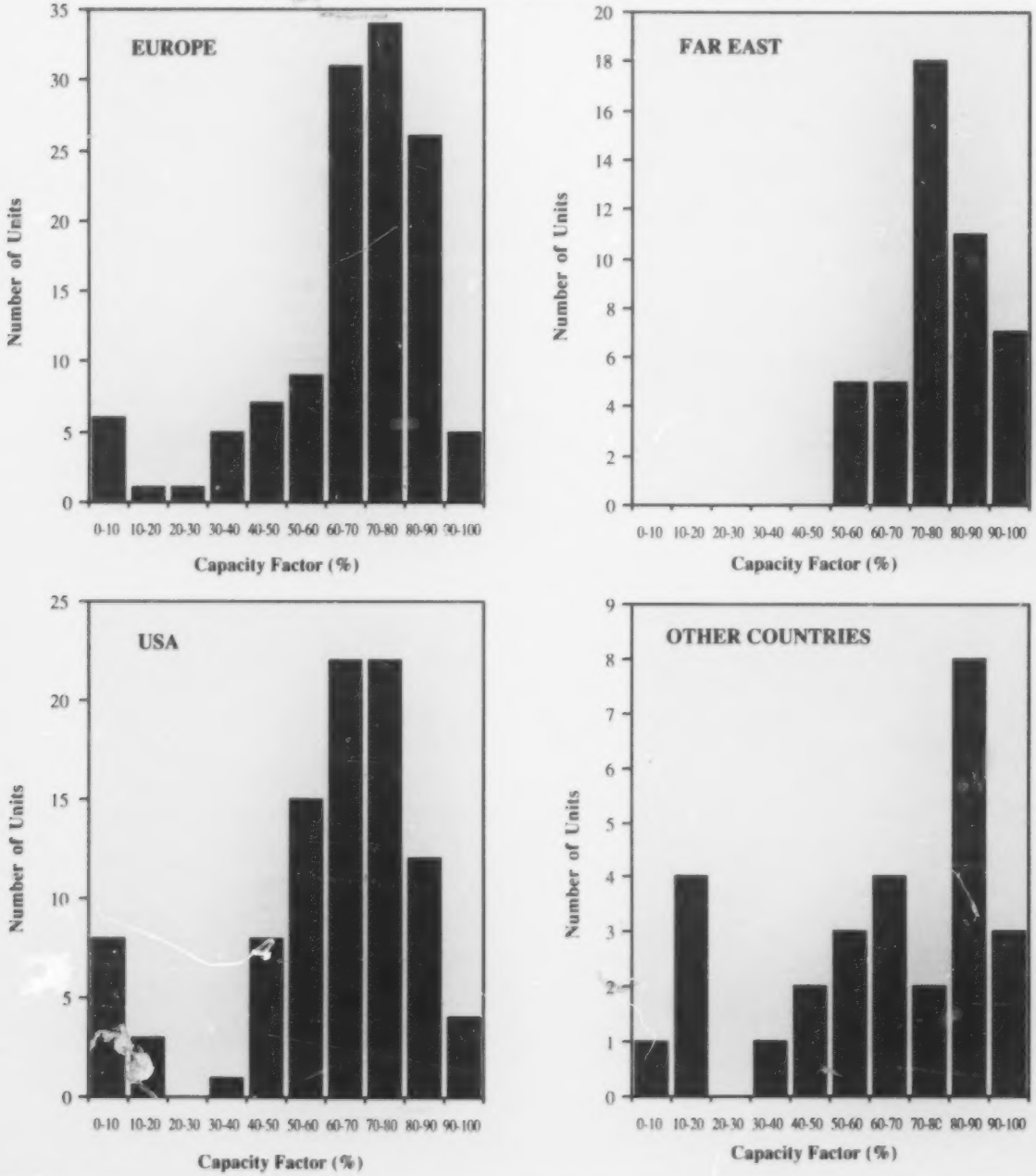

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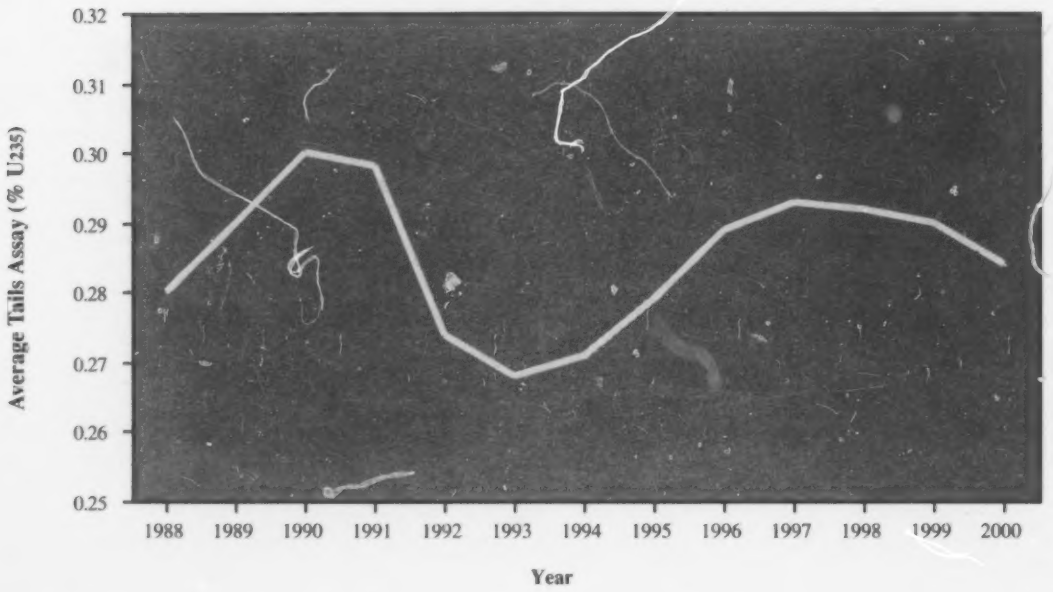
Figure 5
FORECAST OF ENRICHMENT TAILS ASSAY
Free Market Condition



on Nuexco's forecast of spot uranium prices and SWU prices.

Figure 5 shows the forecast for the enrichment tails assay for the free market case. Note that during the period 1990 through 1993 the tails assay drops from 0.3 percent to a little under 0.27 percent, holding down the rate of increase in uranium consumption. From 1993 to 1996, a notably large growth in consumption occurs, spurred primarily by:

- an increase in the tails assay from 0.268 to 0.289, which by itself increases consumption by 4.4 percent,
- a normal increase in enriched uranium needs as installed capacity grows,
- the assumption that the capacity factor will gradually increase,
- larger than average capacity additions in 1997-99 which, due to the lead requirements for fuel, accounts for an increase in uranium demand several years earlier.

Over the study period, the tails assay averages 0.285 percent.

Recycle of Uranium and/or Plutonium

The increased use of nuclear fuel reprocessing by non-US utilities will affect uranium material balances through additions to supply of recycled uranium (REPU) and reductions in demand for enriched uranium due to mixed uranium-plutonium oxide (MOX) fuels. Although current prices of uranium and enrichment services do not favor recycling on a purely economical basis, Argentina, China, France, Japan, West Germany, the United Kingdom and the USSR have committed to the reprocessing of spent nuclear fuel. Nuexco estimates that some 45 million pounds U_3O_8 equivalent, or 2.6 percent of total forecast uranium consumption, will be provided through existing reprocessing contracts.

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Free Market Condition - Reference Growth Case

Total consumption over the study period is forecast to be 1736 million pounds U_3O_8. Uranium consumption in 1988 is 108.6 million pounds and 151.5 million pounds in 2000, averaging 135.5 million lbs per year. This corresponds to a 2.8 percent average annual growth rate. The top five user countries over the study period are:

United States	31%
France	20%
Japan	14%
Germany	8%
Canada	4%
Total	77%

Figure 6 shows projected annual uranium consumption by region. Europe is the number one regional consumer with requirements of approximately 745 million pounds U_3O_8 over the study period. France consumes the most uranium within that region, followed by West Germany and the U.K. The overall increase in demand over the thirteen years averages 1.2 million pounds/year, the equivalent of a compound growth rate of 2.3 percent per year.

The USA is expected to consume approximately 537 million pounds through 2000, showing a growth rate of about 0.9 percent per year.

In the Far East, consumption should average about 26.2 million pounds annually, with total consumption of approximately 341 million pounds. The annual growth rate for consumption in the Far East is 6.6 percent. Japan is clearly the primary consumer in the Far East, and also shows the highest growth rate in that region.

Comparison With Previous Year's Forecast

Some of the differences in the current and prior year forecasts are:

- This year, Nuexco utilized a year-by-year enrichment tails assay optimization procedure. The tails assay selection was based on minimizing the enriched product cost using the forecast natural uranium and separative work (SWU) prices for each year. This yielded a higher enriching tails assay than in last year's forecast (0.285 percent U_{235} compared to 0.25 percent in 1987). This alone causes consumption to rise by about 7.1 percent.
- Average projected installed electric generating capacity is 0.7 percent less than last year, thus reducing consumption by about the same amount.
- This year's average plant capacity factor over the study period is 69.4 percent, down 2.3 percent from last year's value of 71.0 percent. For the reference growth forecast, reload fuel accounts for about 95 percent of total estimated consumption; therefore, the capacity factor reduction lowers total consumption by about 2.1 percent.
- Enrichment/burnup relationships and other technical changes in the consumption model reduce consumption by about 3.4 percent.

All together, these differences result in a net 0.6 percent increase in the total consumption forecast.

Comparison of Nuexco Forecast with Other Forecasts

The Energy Information Administration (EIA) report entitled "World Nuclear Fuel Cycle Requirements 1987" provides some data on its own and other uranium consumption forecasts.

Based on the available information, the major differences in the EIA and Nuexco reports are:

- Nuexco uses a higher tails assay value (averaging 0.285 percent versus EIA's 0.256 percent).
- Nuexco's electric generating capacity factor is about 3.4 percent higher than EIA's, which affects reload fuel requirements.

After adjustment for the above variables, Nuexco projects a 4.5 percent higher level of consumption than EIA.

The Uranium Institute projection for 1988-2000 is 1628 million pounds total uranium consumption. The largest difference in the Uranium Institute and Nuexco forecasts results from the Uranium Institute using a much lower tails assay (0.225%). This accounts for a 12.2 percent difference in consumption. The Uranium Institute has a higher projected nuclear power capacity than Nuexeo, but capacity factors are similar. After adjustments, the Uranium Institute has a 1.2 percent higher consumption forecast than Nuexco.

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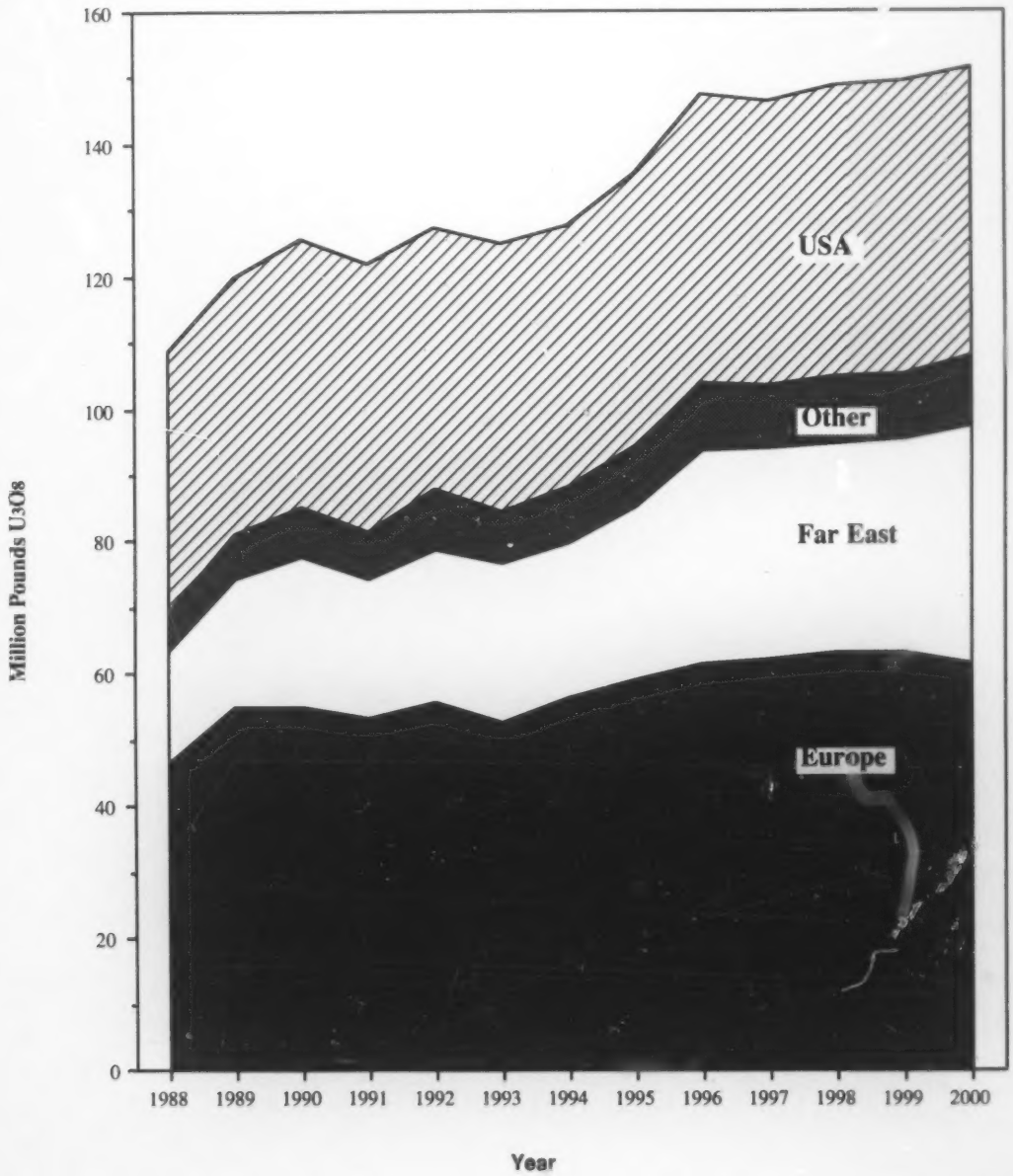
Figure 6
FORECAST OF ANNUAL URANIUM CONSUMPTION BY REGION
Free Market Condition - Reference Growth Case



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PRODUCTION TECHNOLOGY - SHAFT DRILLING

Introduction

Many individual factors have contributed to the evolution of uranium production technology and the increasing efficiency of exploitation. These improvements have allowed the industry to maintain a high level of production in spite of decreasing uranium prices. This process is ongoing, and additional improvements may be anticipated in the future.

An emerging technology which is providing an increasing contribution to uranium production is radiometric sorting of uranium ores (see Nuexco Report No. 232). In addition, shaft drilling and the related fields of raise and tunnel boring are finding increasing application in uranium mining systems and in systems being developed for the disposal of nuclear waste.

Shaft drilling has even played a role in the construction of a nuclear power plant. The Seabrook plant in New Hampshire utilizes fourteen drilled shafts in its cooling water system. Located one mile offshore in the Atlantic Ocean, these shafts connect with the plant by means of a tunnel three miles in length. The shafts were drilled from a jack-up barge in 50-75 feet of water and reached a total depth of about 160 feet.

This review of shaft drilling covers the history of its development, current technology and equipment, and its application to uranium production.

History

Big-hole shaft drilling dates back to the mid-1800s in the coal mining industries of the Netherlands and Germany. By the early 1900s, the Honigmann method (Figure 7), which incorporates most features of current methods, was being used in Germany to drill through soft, water-saturated sediments to depths in excess of 1300 feet, with diameters of up to 24 feet. Average progress was reported to have been in the range of 30 to 60 feet per month while costs were approximately $750 per foot.

A number of shafts were drilled in the USA in the 1930s with calyx drills - blunt drill pipes rotating on small chilled-steel shot which were poured into the bottom of the hole. These drills actually cut a large-diameter core which had to be broken off and hoisted out of the drill hole. Diameters ranged up to six feet, depths to 1200 feet,

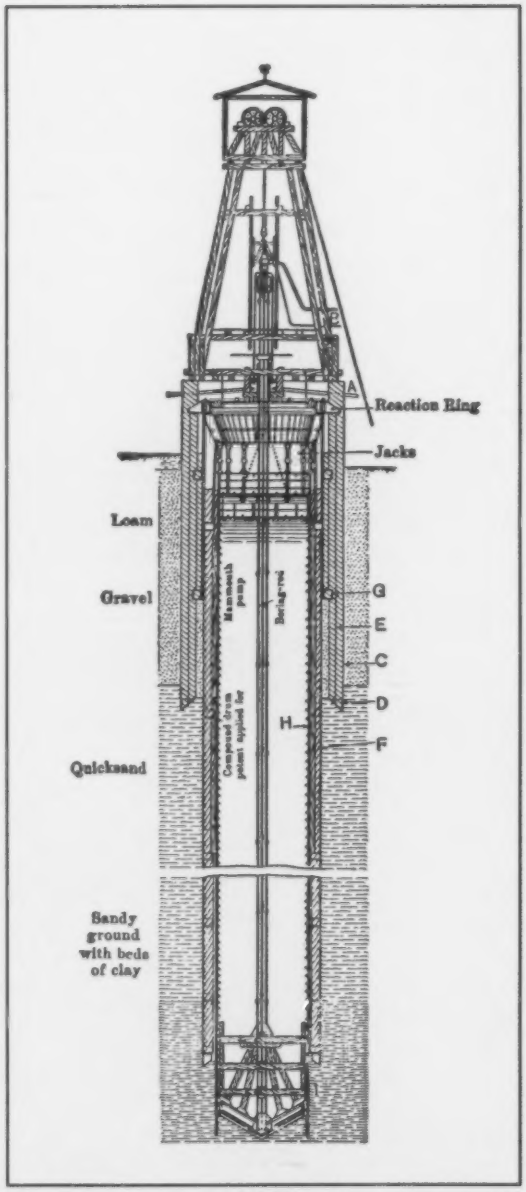

Figure 7. Honigmann Method. *Mammoth Pump and Borer. Shafts IV and V, Rheinpreussen Colliery, Germany. A, Suction Pipe and Overflow; B, Compressed Air; C, Caisson: D, Shoe; E, Anchor Rods; F, Compound Lining; H, Cast-iron Lining (Riemer).*

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progress to 150 feet per month and costs averaged about $20 per foot.

The late 1950s saw a rapid expansion of big-hole drilling in the USA as eastern coal companies tried out this new technology. The construction of liquified petroleum gas (LPG) storage caverns where some fifty 42-inch diameter access shafts were drilled during the period of 1956-1965 provided additional impetus to the development of shaft drilling.

The cessation of atmospheric nuclear weapons testing in the late 1950s caused a surge of big-hole drilling at the Nevada Test Site, which has been the center of research and development activities for big-hole drilling ever since. Over 450 large-diameter holes have been drilled on the test site, the deepest of which was drilled to 5050 feet and was six feet in diameter.

Phillips Petroleum was the first US uranium producer to utilize big-hole drilling. In 1958, Phillips drilled two shafts to depths of 930 and 1432 feet at its Grants, New Mexico operation. Each shaft had a drilled diameter of 46 inches (four separate passes were required to reach this size), and a cased diameter of 36 inches. The deeper hole was completed in 64 days and the shallower hole in 50 days. Kermac Nuclear, Rare Metals Corporation, and Union Carbide were other early users of big-hole drilling in the US uranium industry. Costs ranged from $50 to $100 per foot and excellent progress of up to 200 feet or more a week was frequently made for shafts up to 48 inches in diameter. These smaller shafts were used chiefly for ventilation. Depths were usually moderate - 600 to 1000 feet.

In 1963, two trapped coal miners in a Pennsylvania mine were rescued through a 26-inch diameter hole drilled to an air pocket at a depth of 350 feet. Although the pocket was not intersected until the third attempt, the operation is credited with providing impetus and experience to big-hole drilling. The South African Chamber of Mines also developed mine rescue capability through big-hole drilling and completed 700 feet of a 25-inch diameter hole in five days.

Throughout the 1960s, drill hole diameters increased substantially and, in 1970, Kerr-McGee Corporation completed a 16-1/2- foot diameter drilled shaft to a depth of 784 feet in the Ambrosia Lake area of New Mexico. The shaft was drilled and lined in less than six months and marked the development of Kerr-McGee's ninth uranium mine in the district.

Union Carbide, one of the first major US uranium producers, utilized big-hole drilling for all access and ventilation shafts at its Thunderbird and Rox projects in the Gas Hills area of Wyoming. These projects were developed in 1963 and 1964, respectively, at depths of about 400 feet. The hoisting shafts were drilled to a diameter of 60 inches and lined with 48-inch casing. The 60-inch holes were drilled in a single pass with a three-stage (26", 48", and 60") bit. While drilling and casing costs totaling about $178 per foot were slightly higher than costs for a comparable conventional shaft, timing considerations imposed by the Atomic Energy Commission's schedule of allocation provided an incentive for quick development. The mines had a production capability of 250 tons of ore per day through each of the 48-inch shafts.

One of the more recent major shaft drilling projects undertaken for uranium production was the Crown Point project, a joint venture of Wyoming Mineral Corporation and Conoco, Inc. This project included three closely-spaced shafts, one at 120 inches in diameter and two at 72 inches in diameter, all drilled to a depth of about 2200 feet near Crownpoint, New Mexico in 1980-1981. It took 363 days to drill and case all three shafts — an average rate of progress of 18 feet per day.

The largest drilled shaft in the free world was completed in Australia as a ventilation shaft for a nickel mine in 1983. At 14 feet in diameter and 2460 feet in depth, some 380,000 cubic feet of rock was drilled and pumped to the surface. Drilling required 328 days for an average rate of progress of 7.5 feet per day. Total cost was US $15 million, or $1,600 per foot. While this rate and cost are not particularly good, the exploration shaft for this mine required almost three years to sink using the conventional method.

Technology and Equipment

The actual drilling process for big holes requires a combination of massive, powerful, finely-machined equipment rarely encountered in other applications. It requires cutters, cutter heads, stabilizers, collars, drilling pipe, and drilling rigs of the largest sizes to operate as a unit within very narrow tolerances in an inhospitable environment. The basic technology of big-hole drilling has been borrowed, in most cases, from the petroleum industry and adapted to more specialized needs. This technology continues to evolve through innovation, particularly in the areas of cutter design, cuttings removal, and lining.

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Figure 8. Cutter head with milled tooth cutter. *(Photo courtesy of the Earth Mechanics Institute.)*

Cutters and Cutter Heads

Drill head cutters consist of three general types: milled tooth, tungsten carbide insert, or disc. Milled tooth cutters are, in essence, a series of steel wedges formed on a tapered, circular core which "rolls" across the area to be cut and indents and craters the rock. (See Figure 8.) These cutters are generally applicable to softer formations because bit wear can be excessive in harder material. Tungsten carbide inserts are set into tapered rollers and may be used in harder, more abrasive formations. Disc cutters are shaped like a pair of cymbals and also roll across the area to be cut, indenting and cratering in a continuous band. Disc cutters tend to produce larger chips than toothed cutters, an advantage in breaking the rock, since less energy is consumed per unit of rock broken. As a rule, energy input in rock breakage is inversely proportional to the size of the pieces produced.

A series of cutters are usually emplaced upon a drill head in such a manner as to provide coverage of the entire rock face as the head rotates. Cutter types and sizes may be combined for optimum cutting and coverage. The drill head configuration may be a flat, domed, or narrow cone. In general, flat configurations are amenable to limited deviation and conical shapes provide increased penetration rates.

Drill Pipe

Drill pipe for big hole drilling serves two purposes: 1) transmitting rotational force to the drill head, and 2) channeling drilling fluids and/or cuttings. Standard oilfield drill pipe in 30 to 60-foot lengths is used. The outside diameter is usually 13-3/8 inches and each length of pipe is fitted with a welded tool joint at each end. The tool joint is simply a short length of pipe flattened on opposing sides with tapered threads on the outside end. The flattened portion serves as a grip when connecting, disconnecting, or rotating the pipes, and the tapered threads enable the pipes to be screwed together quickly.

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Stabilizers and Collars

A grouping of stabilizers and collars is installed on the drill pipe above the drill head. The stabilizers limit horizontal movement of the drill head; one is located immediately above the drill head, the other is located further up on the drill pipe above the drill collars. The stabilizers comprise several rollers, mounted vertically upon a circular shell, and are set at the exact gauge of the drill hole. Drill collars provide much of the weight required to force the drill bits into the rock. These collars, which look like steel doughnuts fitted on the drill pipe, are cast from steel or iron and may weigh up to five tons each.

In big-hole drilling applications, it is not unusual for the total weight of the drilling assembly — cutter head, stabilizers and collars — to exceed 250 tons. This weight forces the cutters into the rock causing displacement, dislodging, crushing, or spalling of fragments. As a general rule, harder rocks require more force to produce the same sized chips as those produced in softer rocks.

Drill Rigs

Two types of drill rigs are used for big-hole drilling: standard oil field rigs modified to meet the specific requirements of big-hole drilling, and rigs specially designed for those requirements.

In either case, the requirements are substantial and result in rigs of immense capabilities.

Standard oil field drilling rigs are known by their tall derrick structures mounted over the drilling platform. These structures allow the drill pipe to be broken into long lengths when "tripping" (moving the bit into or out of the hole) and stored within the structure itself. Specially-designed rigs are shorter than standard rigs and may incorporate a twin-tower design which supports a hydraulically-controlled head block.

These rigs must have:

- a large lifting capacity for the drill string as well as for lining emplacement (up to as much as 2,000,000 pounds),
- the ability to impart rotational force to the cutter head (up to as much as 500,000 ft-pounds), and
- the capability of handling many kinds of specialized service functions.

Lifting capacity is a function of the combined capacity of the derrick structure and the draw works hoist, while the rotational capacity is provided by a rotating table which grasps and turns the drill pipe at the tool joint. The table may be driven by either chain or hydraulics, but, in either case, some limiting feature is usually provided so that excess torque will not destroy the table or the drill string.

Service functions include provision for bit replacement, mud handling, deviation surveying, lining installation, fishing for lost tools, and grouting.

CUTTINGS REMOVAL

The success of the drilling process can be measured by the difficulties encountered in the removal of cuttings. Large cuttings, indicative of efficient drilling, may be difficult to remove from the hole, and faster drilling progress requires that more material be removed from the hole per unit of time.

Cuttings removal is invariably accomplished by flushing the drill hole with some mixture of air, water, mud, and additives. Flow rate and density are the primary variables. Obviously, higher flow rates and higher densities can remove more and larger particles.

In the early days (1950s) of shaft drilling, most drill hole flushing used the direct method of forcing a fluid down the center of the drill string and up the annulus between the drill string and the hole wall. As hole diameters increased, however, from a few feet to many feet, the difficulty of maintaining a high upward velocity in the drill hole became almost insurmountable. (Pumping requirements increase in relation to the square of the hole diameter.) Consider, for example, a three-foot hole drilled with 6-3/4-inch pipe and an eight-foot hole drilled with 13-3/8 inch pipe. To maintain equal up-hole velocities the eight-foot hole would require seven times the pumping capacity. The velocity requirements also increase for larger particles. These relationships led to a reconsideration of conventional methods, and resulted in the development of "reverse" circulation drilling wherein the drilling fluid moves down the drill hole and up the drill pipe. The small inside diameter (ID) of the drill pipe allows very high fluid flow velocities to be achieved inside the pipe. Of course, cutting size is limited to the ID of the pipe, which for 13-3/8-inch pipe amounts to about 11 inches.

Air lift is the principal means of producing this type of circulation. This method requires air to be introduced under pressure into the drill pipe at some distance below the fluid level outside of drill pipe. The rising air bubbles reduce the density of the fluid within the pipe, stimulating an upward flow. The cuttings-laden fluid can then be pumped from the top of the drill pipe to a cuttings disposal area. In most cases, particularly where some type of fluid

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additives are used, it may be desirable to separate the cuttings from the fluid so that the fluid may be reused. This separation usually entails two processes: screening and settling. Screening removes the larger particles, and settling allows the smaller particles to gravitate to the bottom of, for example, a mud pit while the clean fluid flows out the top of the pit. Cyclone separators have also been used effectively for this purpose.

The most common fluid used in big-hole drilling is water and the most common additive is a finely-ground bentonitic clay which swells appreciably upon contact with water. The clay, in essence, seals the sides of the drill hole and prevents loss of the drilling fluid into the cracks and interstices of the rock. Water and mud also exert hydrostatic force against the sides of the drill hole which prevent or minimize caving and sloughing of loose material.

During the drilling process, the drilling fluid flows downward through the drill hole and sweeps across the bottom of the hole to the drill pipe intake. This sweeping action cleans the chips from the bottom of the hole on a continuing basis. The bottom-hole configuration also affects cuttings removal. A flat face requires relatively high velocities which are difficult to achieve on the perimeter of the hole, while a sloping face provides a gravity-assist.

In a number of cases, air alone has been used as the drilling medium to remove cuttings and to cool the cutters. A water mist, detergents, or other additives can enhance the carrying power of air. Generally, air is used only in relatively dry, unfractured ground.

A recent modification of the reverse circulation system utilizes double-wall drill pipe to maintain all fluid movement, up and down the hole, inside of the drill string. This method reduces hydrostatic pressure on the drill hole wall since only the bottom portion of the hole must be filled with fluid.

LINING

Drilled shafts, which cause little if any deterioration of the material penetrated, may require a lining either to ensure wall stability or to limit the inflow of water. Historically, this lining has usually consisted of steel casing, butt-welded and lowered into the drill hole a segment at a time. Approximate thirty-foot lengths are common.

The design and setting of steel casing poses certain problems.

- Hydrostatic forces are much greater at depth (some shafts have been cased to over 5,000 feet).
- The weight of the casing may exceed the lifting capacity of the rig.

The problem of high hydrostatic loads at depth may be addressed by varying the casing thickness, adding stiffener rings, or some combination thereof. Casing thickness is usually in the range of 1/2 to 3/4 inches near the top of the hole and as much as 1-3/4 inches near the bottom of the hole. Stiffener rings may vary in width, thickness, and spacing depending upon pressure. A safety factor of 50% is usually added to the expected pressure in order to provide some margin for design or construction errors.

When the total weight of the casing exceeds the lifting capacity of the rig, it is necessary to "float" the casing into place. First, the down hole end of the first casing is fitted with a hemispherical bulkhead and lowered into the drill hole which is still filled with drilling mud. Some drilling mud then is pumped into the casing to force it further down the hole so that it floats at an appropriate and convenient level. Buoyancy is created by maintaining the fluid level inside the casing at a lower level than the fluid outside the casing. The casing need not be entirely self-supporting in this way since the rig is available to assist with the process. The next section of casing is lowered onto the floating casing, matched for alignment, and butt-welded (either manually on semi-automatically). More mud then is pumped into the casing to lower it for the next segment and the process is repeated.

It is important to recognize, however, that the casing must be designed to withstand the pressure differentials created by the floating process as well as in-place hydrostatic and grouting pressures.

Grouting pressures are encountered after the casing is emplaced the full length of the drill hole. It is then necessary to seal the annulus between the casing and the drill hole with concrete (or grout) in order to prevent water flow up or down the hole and to provide additional lining strength. Grout is pumped into the annulus in a series of stages from bottom to top through pipes installed in the annulus. The grout, being heavier, displaces the mud/water mixture progressively. Additional grout fittings are provided at intervals throughout the casing for final checking and sealing after the interior of the casing has been dewatered.

A number of casing collapses have been recorded, including:

- At Bokum's Marquez project, which was funded primarily by Long Island Lighting Company (LILCO) for

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fuel supply at Shoreham, several ventilation/service shafts in the range of five to six feet in diameter were to be drilled. The first such shaft was drilled 78" in diameter to a depth of 2080 feet; a 60" casing was to be installed. For additional strength, the steel casing was fitted with channel stiffeners. Provision for grouting was made with a single grout line guide which was attached to the casing at notches made in the stiffening rings. This was done to minimize the outside diameter of the combined elements. During flotation of the casing for installation, a 40-foot joint of casing collapsed, apparently initiated by the notch in the stiffening ring. The casing flooded, overloaded the rig hoisting system (which failed), and fell 100 feet to the bottom of the hole. Repairs were attempted, but an effective water shutoff was never achieved and the shaft was never completed.

• In 1982 at a lead mine in Missouri, the steel casing for a 112-inch diameter by 1350-foot deep drilled shaft failed at a depth of about 800 feet during dewatering. After several unsuccessful attempts to seal the crack by grouting, a team of saturation divers was brought in to weld a patch over the crack. The logistics of the situation were formidable: a saturation chamber on the surface provided living quarters under pressure for the duration of the job, a submersible diving chamber provided transportation from the surface to the depths of the shaft, and an underwater welding habitat provided a working platform sealed by inflatable packers. After inflation of the packers, high-pressure air expelled water from the habitat. The crack was successfully repaired in 15 days, with the decompression requirement of 24 hours per 100 feet of depth accounting for the majority of that time (8 days).

Deviation Control

Verticality and straightness parameters are of primary concern for mine shafts dedicated to hoisting, since the hoisting ropes should hang free and clear of all obstructions and the horizontal forces on high-speed conveyances and their supports must be limited. These requirements do not apply for ventilation shafts. The installation of steel shaft linings also allows only minimum tolerance in alignment.

While drilling technique has a definite impact on hole deviation, the physical characteristics of the formation being penetrated are the principal cause of deviation. Drill holes tend to orient themselves perpendicularly to the bedding planes of the rock being drilled. Thus, in easterly-dipping strata, one would expect a drill hole to deviate to the west. The outlook for minimum deviation is poor in steeply-dipping rocks, particularly if the layers are thin and of varying hardness.

The four general methods of limiting deviation in big-hole drilling are 1) "steering" the drill bit; 2) guiding the drill bit by use of a small-diameter pilot hole; 3) stabilizing the drill string; and 4) utilizing the natural "plumb-bob" effect of the drill string.

Steering is typical of small diameter drill holes where a whipstock or in-hole directional bit may be used to direct the hole in the desired direction. While rarely used in big-hole drilling, steering, by means of an off-center stabilizer, has been reported.

Small diameter pilot holes have been used extensively in big-hole drilling to ensure proper direction and alignment at minimal cost. In many cases, pilot holes have been reamed one or more times to complete large diameter holes with rigs of minimal torque capabilities. To use a pilot hole as a guide hole, it is only necessary to provide a short "stub" on the bottom of a drill bit. This stub rotates within the pilot hole and guides the larger bit. Specialized, continuous systems of directional drilling are now available, and are expected to play an increasing role in shaft drilling.

Stabilization of the drill string is controlled by a series of circular stabilizers mounted above the cutter head on the drill string.

The natural plumb-bob effect of the drill string itself can be used effectively only when the string is in significant tension. Thus, more weight is added to the bit than that needed for penetration and the rig is actually lifting on the drill string at all times. During shaft drilling at the Crown Point uranium project in New Mexico, for example, only 30 percent of the drill string weight was applied to the bottom of the hole. Horizontal displacements for the three shafts were 1.03 feet, 1.33 feet and 0.84 feet at final depths of about 2200 feet.

In most cases, shaft drilling alignment is determined periodically with down-the-hole survey instruments common to the petroleum industry.

Operating Characteristics

Mechanically excavated mine openings have several advantages over those completed by conventional methods.

1. Conventional drill-and-blast methods are cyclical operations which require personnel to vacate the working

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area prior to detonation of the explosive charges. When drill-and-blast operations are being conducted simultaneously in a number of adjacent areas, substantial coordination is required in order to minimize waiting times. Continuous methods of excavation require little coordination with adjacent areas and can rapidly build to an efficient, ongoing routine.

2. Mechanically-excavated openings exhibit smooth surfaces which provide for highly-efficient flows of ventilation air and which require much less initial ground support than their conventional counterparts. Blasting operations, even when carefully controlled, fracture and weaken the surrounding rock, necessitating an ongoing maintenance program. Maintenance requirements are likely to be much less in a drilled shaft since the integrity of the rock is usually unaffected by the drilling process. It is notable, however, that conventional methods are much more capable of adapting to changing conditions than are mechanical methods.

3. The safety advantages of a drilled shaft, during both construction and operation, may be substantial. During the period 1971-1978, 44 fatalities were recorded on shaft sinking projects in the USA, only one of which occurred at a bored shaft. During construction of the conventional exploration shaft at the Australian nickel mine, five miners were killed and 63 lost-time accidents occurred. With the drilled shaft, only seven lost-time accidents occurred and there were no fatalities.

4. Bored shafts may offer significant savings in time. Progress for a drill-and-blast shaft may average 200 feet per month under favorable conditions, compared to 100-200 feet per week for shaft drilling which, in many cases, may be under severe conditions.

Waste Isolation Pilot Plant (WIPP)

In addition to providing access for the development of uranium resources, shaft drilling may also play a major role in the disposal of nuclear waste.

The Waste Isolation Pilot Plant (WIPP) is a test long-term storage project for nuclear waste generated by the US national defense program. This underground repository is located near Carlsbad, New Mexico at a depth of 2150 feet within a series of salt beds 3300 feet thick. Construction commenced in 1981.

Access to the storage-level chambers is gained through a 12-foot diameter shaft drilled to 2300 feet. Upon completion of this first shaft, a six-foot diameter ventilation shaft was drilled to a depth of 2200 feet. The drilling fluid was saturated brine, which prevented dissolution of the salt beds being penetrated. Table 3 summarizes some of the features of this project.

Table 3
FEATURES OF WIPP DRILLED SHAFTS

Item	Access Shaft	Ventilation Shaft
Diameter	142 inches	72 inches
Depth	2298 feet	2196 feet
Deviation	1.59 feet	2.25 feet
Drilling time	112 days	45 days
Penetration Rate	1.11 ft/hr	2.57 ft/hr
Total time	215 days	69 days

The access shaft was lined from the surface to a depth of 850 feet with a circular steel liner backfilled with concrete. Below 850 feet, the shaft was within salt beds requiring no lining. The ventilation shaft was unlined in its entirety and was later enlarged conventionally. The total cost of completing these shafts was $7.8 million.

Ironically, construction of the proposed civilian nuclear waste repository at Yucca Mountain on the Nevada Test Site will probably not use shaft drilling for construction of access shafts. In this instance, the Department of Energy considers the ability to continuously view, map, and test all rock formations penetrated to be of more importance than the integrity of rock adjacent to the shaft. Conventional means of shaft sinking permit such access much more readily.

Current Applications

In recent years, many of the world's richest uranium deposits have been discovered in the Athabasca Basin of northern Saskatchewan. Serious consideration is being given to shaft drilling methods as a possible means of developing and exploiting those deposits. They occur in soft, saturated rocks and, because of their high radioactivity, cannot be mined by methods which bring personnel into close contact with the ore.

Shaft drilling offers both ground control and remote operating advantages to a mining system for these

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deposits. In this case, a series of large-diameter holes would be drilled from a development level immediately above the deposit, drilled ore could be pumped to the surface as a slurry, and the voids created could be back-filled with a low-grade concrete. The Cigar Lake and Midwest projects have such systems currently under evaluation.

The excavation cost for the large Australian nickel mine shaft was roughly $160 per ton of material removed from the drill hole. If that cost could be achieved on the Cigar Lake orebody (average grade about 14% U_3O_8), the resulting "mining cost" would be about $0.60 per pound U_3O_8 mined. Even at current U_3O_8 prices in the $15-16 per pound range, an ample margin would likely be available to cover the other costs of exploitation.

As shown below, the method also holds significant promise at the lower grades reported for other undeveloped Saskatchewan orebodies.

Ore Deposit	Ore Grade % U_3O_8	Shaft Drilling Mining Cost ($/lb U_3O_8)
Cigar Lake Main Pod	14.4	0.56
Cigar Lake Extension	4.8	1.67
Dawn Lake	1.97	4.06
McClean Lake	1.8	4.44
Midwest	1.25	6.40

By comparison, mining costs at Energy Fuels breccia pipe operations in northern Arizona are estimated at $3-4 per pound U_3O_8. Mining costs for low-grade mines, however, such as those in the Elliot Lake district of Canada are much higher, in the range of $10-15 per pound U_3O_8.

Figure 9. *Shaft drilling rig at Energy Fuels' Pigeon mine in northern Arizona. (Photo courtesy of Energy Fuels.)*

Summary

In conclusion, shaft drilling may not be the favored method in a majority of cases since costs can be relatively high, particularly when competition among the few companies with shaft drilling capability is weak. In other cases, logistics may be a problem, water may be scarce, or even disposal of the drilling mud may prove difficult. There can be no doubt, however, that shaft drilling offers a very real alternative to conventional methods in circumstances where the combination of water and unstable ground occur.

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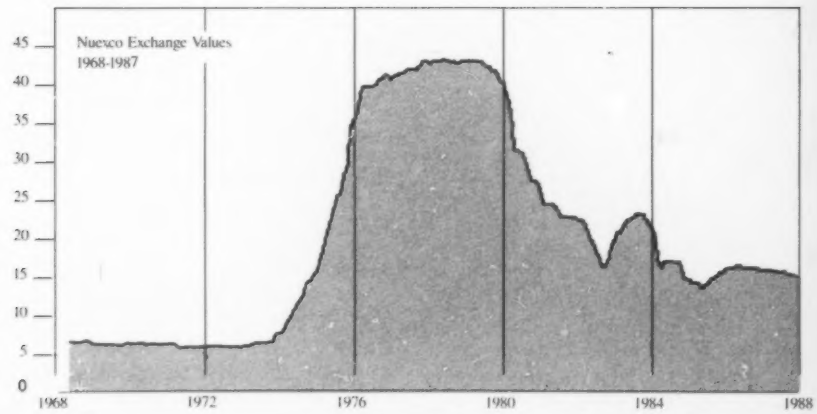
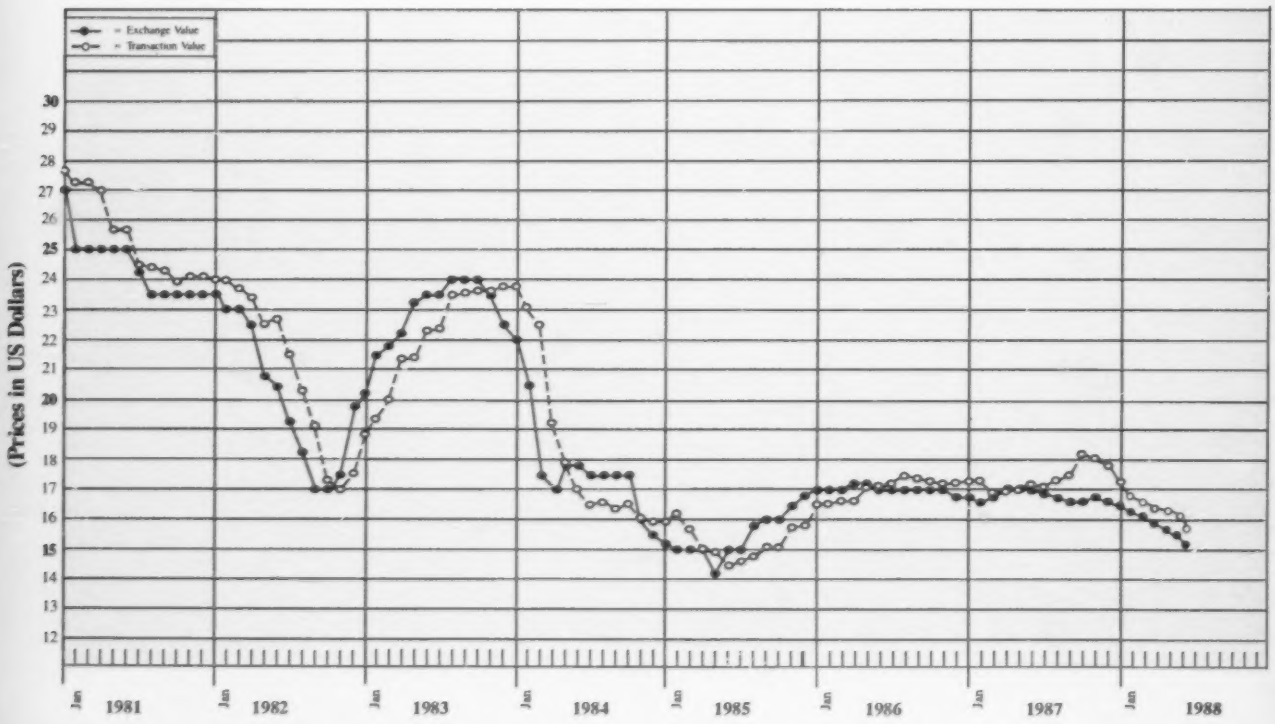
HISTORICAL MARKET DATA





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HISTORICAL EXCHANGE VALUES

Determined as of the last day of the month indicated ($US/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	—	—	—	—	—	—	—	6.35	6.35	6.40	6.45	6.50
1969	—	6.35	6.10	6.10	6.25	6.25	6.20	6.20	6.15	6.15	6.15	6.20
1970	6.30	6.30	6.30	6.30	6.30	6.30	6.30	6.20	6.15	6.15	6.15	6.15
1971	6.20	6.20	6.20	6.20	6.15	6.05	6.00	5.95	5.95	5.95	5.95	5.95
1972	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95	5.95
1973	5.95	6.00	6.10	6.20	6.45	6.50	6.50	6.50	6.50	6.50	6.75	7.00
1974	7.70	7.90	8.00	9.00	9.50	10.50	11.50	12.00	12.50	14.00	14.75	15.00
1975	16.00	16.00	18.00	20.00	21.00	23.00	24.70	26.00	26.00	28.50	30.00	35.00
1976	35.20	37.00	39.25	40.00	40.00	40.00	40.00	40.40	41.00	41.00	41.50	41.00
1977	41.35	41.50	41.60	41.60	42.00	42.25	42.25	42.25	42.40	42.75	43.20	43.20
1978	42.90	43.25	43.25	43.25	43.40	43.40	43.40	43.10	43.25	43.00	43.25	43.25
1979	43.25	43.25	43.25	43.25	43.25	43.00	42.70	42.70	42.20	42.20	41.00	40.75
1980	40.00	38.00	35.00	32.00	32.00	31.50	31.50	30.00	28.50	28.00	28.00	27.00
1981	25.00	25.00	25.00	25.00	25.00	24.25	23.50	23.50	23.50	23.50	23.50	23.50
1982	23.00	23.00	22.50	20.75	20.50	19.25	18.25	17.00	17.00	17.50	19.75	20.25
1983	21.50	21.75	22.25	23.25	23.50	23.50	24.00	24.00	24.00	23.50	22.50	22.00
1984	20.50	17.50	17.00	17.75	17.75	17.50	17.50	17.50	17.50	16.00	15.50	15.25
1985	15.00	15.00	15.00	14.25	15.00	15.00	15.75	16.00	16.00	16.50	16.75	17.00
1986	17.00	17.00	17.25	17.25	17.00	17.00	17.00	17.00	17.00	17.00	16.75	16.75
1987	16.65	16.75	17.00	17.00	17.00	16.90	16.75	16.65	16.65	16.75	16.65	16.55
1988	16.30	16.15	15.90	15.75	15.40	**15.10**						

HISTORICAL US PREMIUM (Relative to the Exchange Value)

Determined as of the last day of the month indicated ($US/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1986	—	—	—	—	—	—	—	—	—	—	0.65	0.75
1987	0.85	1.00	1.50	1.50	0.90	0.60	2.50	2.35	2.10	1.65	0.85	0.65
1988	0.70	0.50	0.15	.25	.60	**0.00**						

HISTORICAL TRANSACTION VALUES

Determined as of the last day of the month indicated ($US/lb. U_3O_8)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1976	—	—	—	—	39.60	39.70	39.70	40.40	40.30	40.60	40.70	40.70
1977	41.30	41.30	41.40	41.50	42.80	42.90	43.00	42.60	42.50	42.80	42.90	42.90
1978	43.10	43.30	43.70	43.60	43.60	43.20	43.30	43.40	43.40	43.60	43.40	43.70
1979	43.60	43.80	43.70	43.40	43.60	43.70	43.70	43.60	43.60	43.60	43.50	42.30
1980	42.00	39.30	38.60	38.40	37.90	37.60	37.30	31.30	30.60	29.00	28.70	27.70
1981	27.20	27.20	27.00	25.70	25.70	24.50	24.40	24.30	23.90	24.10	24.10	24.00
1982	24.00	23.70	23.40	22.60	22.70	21.50	20.30	19.10	17.30	17.00	17.55	18.80
1983	19.35	20.00	21.35	21.40	22.35	22.45	23.50	23.60	23.65	23.65	23.85	23.85
1984	23.05	22.50	19.25	17.90	17.00	16.50	16.60	16.40	16.55	16.05	15.90	15.90
1985	16.20	15.70	15.05	14.90	14.45	14.60	14.75	15.10	15.10	15.75	15.80	16.55
1986	16.55	16.70	16.70	17.10	17.05	17.20	17.50	17.45	17.35	17.25	17.30	17.35
1987	17.35	16.90	16.95	17.00	17.20	17.10	17.30	17.55	18.20	18.05	17.80	17.20
1988	16.85	16.65	16.55	16.45	16.10	**15.80**						

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HISTORICAL MARKET DATA

HISTORICAL CONVERSION VALUES

Determined as of the last day of the month indicated ($US/lb. U as UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1981	1.20	1.20	1.20	1.40	1.15	1.15	1.15	1.10	1.10	1.10	1.20	1.20
1982	1.20	1.20	1.20	1.20	1.00	1.00	1.00	0.90	1.10	1.60	1.45	1.45
1983	1.20	1.40	1.40	1.20	1.20	1.20	1.10	1.10	1.00	0.60	0.60	0.60
1984	0.60	0.30	0.80	0.80	0.80	0.90	0.00	0.80	1.00	1.00	0.80	0.80
1985	1.00	1.00	1.00	1.50	1.50	1.60	1.60	1.60	1.60	1.60	1.60	1.60
1986	1.60	1.80	1.90	1.80	1.80	1.80	1.80	1.90	1.90	1.90	1.80	1.80
1987	1.80	1.80	1.80	1.80	1.80	1.80	1.90	1.90	1.90	1.90	1.90	1.90
1988	1.90	1.80	1.80	1.80	1.80	**1.80**						

HISTORICAL UF_6 VALUES

Determined as of the last day of the month indicated ($US/kg. U as UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	—	—	—	40.50	42.50	42.50	44.00	44.50	44.50	46.00	46.00	47.00
1986	47.00	48.00	48.00	48.50	48.25	48.25	48.25	48.00	48.00	48.00	48.00	47.75
1987	47.75	48.00	48.00	48.00	47.75	47.75	47.50	47.00	46.75	47.00	47.00	47.00
1988	46.50	46.00	45.50	45.25	44.75	**44.00**						

HISTORICAL US UF_6 PREMIUM (Relative to the UF_6 Value)

Determined as of the last day of the month indicated ($US/kg U as UF_6)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1986	—	—	—	—	—	—	—	—	—	—	2.50	2.50
1987	2.50	2.50	3.50	3.00	2.25	1.75	6.50	6.00	4.25	3.10	2.25	2.00
1988	1.25	1.25	0.50	0.50	1.00	**0.00**						

HISTORICAL SWU VALUES (at 0.30 Percent Tails Assay)

Determined as of the last day of the month indicated ($US per SWU)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1986	80	80	80	80	75	78	78	78	78	78	80	80
1987	80	80	77	77	75	73	75	75	73	69	73	73
1988	73	73	70	68	68	**68**						

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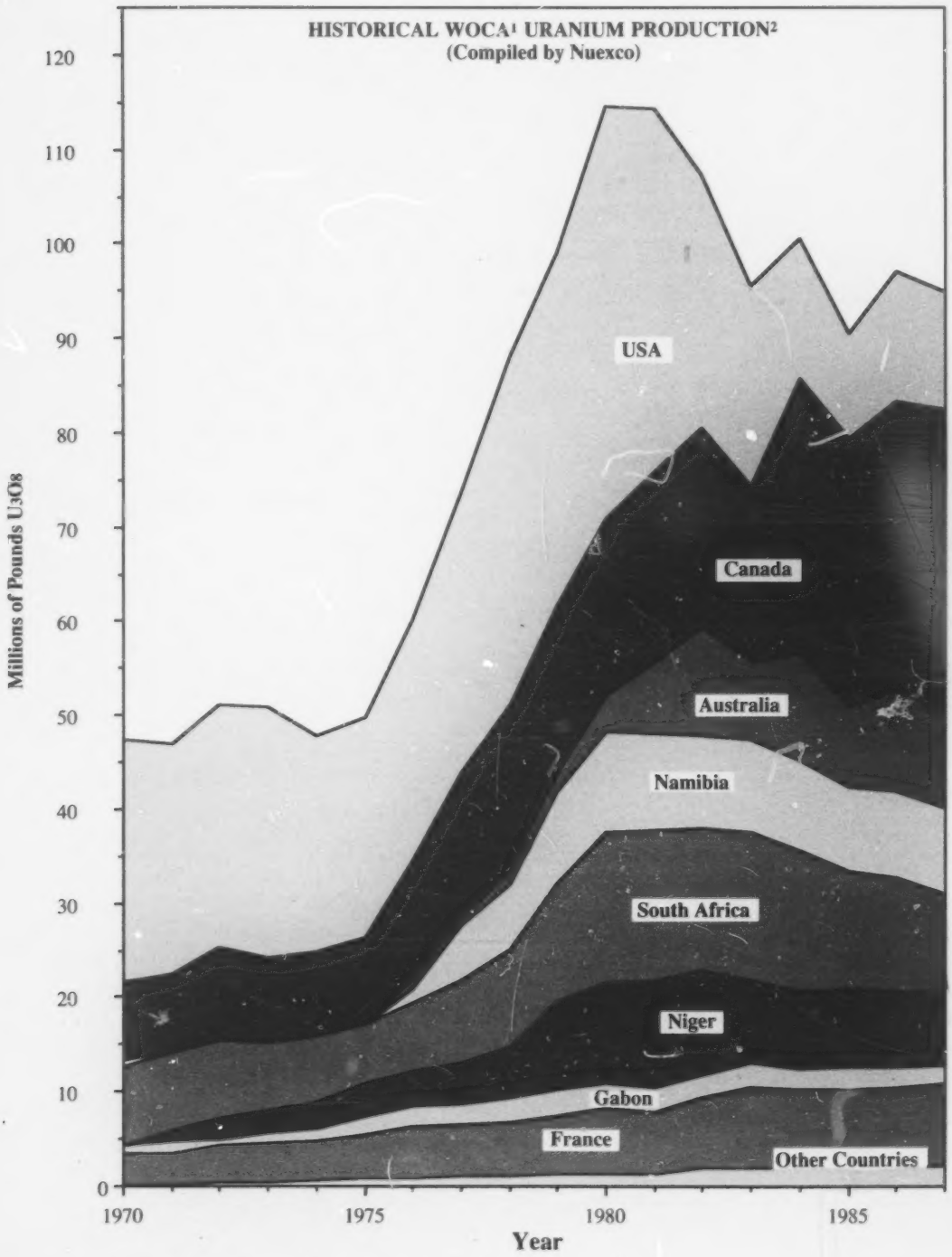

[1]WOCA = World Outside of Centrally-Planned Economic Areas.
[2]1987 production data are preliminary.

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HISTORICAL MARKET DATA

US URANIUM MARKETING ACTIVITIES STATISTICS[1]
(Compiled from data published by the US Energy Information Administration)

Year	Total Production[2] (million pounds U_3O_8)	Deliveries to Domestic Utilities[3] (million pounds U_3O_8)	Average Price of Delivered Uranium ($/lb. U_3O_8)	Quantity of Uranium Imported[4] (million pounds U_3O_8)	Average Price of Imported Uranium ($/lb. U_3O_8)	Quantity of Uranium Exported (million pounds U_3O_8)
1976	25.5	n/a	n/a	3.6	n/a	1.2
1977	29.9	n/a	n/a	5.6	n/a	4.0
1978	37.0	n/a	n/a	5.2	n/a	6.8
1979	37.5	33.0[5]	$23.85[5]	3.0	n/a	6.2
1980	43.7	35.0[5]	$28.15[5]	3.6	$43.10	5.8
1981	38.5	32.6[5]	$34.65[5]	6.6	$32.90	4.4
1982	26.9	27.1	$38.37	17.1	$27.23[6]	6.2
1983	21.2	24.2	$38.21	8.2	$26 16	3.3
1984	14.9	22.5	$32.65	12.5	$21.86	2.2
1985	11.3	21.7	$31.43	11.7	$20.08	5.3
1986	13.5	18.9	$30.01	13.5	$20.07	1.6

[1]Sources: 1979: US Department of Energy, Assistant Secretary for Resource Applications, Office of Uranium Rresources and Enrichment, *Survey of United States Uranium Marketing Activity*, DOE/RA-0053 (Washington DC, July 1980). 1980-1981: US Department of Energy, ASsistant Secretary for Nuclear Energy, Office of Uranium Enrichment and Assessment, *Survey of United States Marketing Activity*, DOE/NE-0013 and DOE/NE-0013/1 (Washington DC, June 1981 and July 1982). 1982: Energy Information Administration, *1982 Survey of United States Marketing Activity*, DOE/EIA-0403 (Washington DC, September 1983). 1983: Energy Information Administration, *Survey of United States Marketing Activity 1983*, DOE/EIA-0403(83) (Washington DC, August 1984). 1984: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1984). 1985: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1985).

[2]Sources: 1976-11982: US Department of Energy, Grand Junction Area Office, *Statistical Data of the Uranium Industry*, GJO-100 (Grand Junction, Colorado, January 1983). 1983: Calculated by the staff of the Nuclear and Alternate Fuels Division, Office of Coal, Nuclear, Electric and Alternate Fuels, Energy Information Administration, from US Department of Energy, Grand Junction Area Office data files. 1984: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1984). 1985: Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey" (1985).

[3]Excludes direct imports by domestic utilities.

[4]Includes imports by domestic utilities and domestic suppliers.

[5]Includes delivery commitments to domestic utilities and agents.

[6]Computation of quantity-weighted average price excludes the quantity associated with a large exchange (swap) transaction that occurred in 1982.

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VOLUME AND PRICE OF URANIUM DELIVERIES TO THE EUROPEAN COMMUNITY[1]
(Compiled from data published by the Euratom Supply Agency)

Year	Volume of Deliveries to the EC[2] (in MTU)	Percentage of Deliveries Made Under Spot Contracts	Medium or Long-Term Contracts[3,4]		Spot Contracts[3,4]	
			Average Price in ECU per pound U_3O_8	Average Price in US Dollars per pound U_3O_8	Average Price in ECU per pound U_3O_8	Average Price in US Dollars per pound U_3O_8
1977	n/a	n/a	n/a	n/a	n/a	$41.00
1978	n/a	n/a	n/a	n/a	n/a	$43.00
1979	10,000	n/a	n/a	n/a	n/a	$44.50
1980	8,600	n/a	n/a	$36.00	n/a	$35.00
1981	13,000	less than 10	n/a	$33.25	n/a	$28.00
1982	12,500	less than 10	ECU 32.25	$32.00	ECU 24.25	$24.00
1983	13,500	less than 10	ECU 34.75	$31.00	ECU 26.00	$23.25
1984	11,000	less than 10	ECU 37.75	$29.75	ECU 24.50	$19.25
1985	11,000	11.5	ECU 38.00	$29.00	ECU 19.50	$15.00
1986	12,000	9.5	ECU 31.50	$31.00	ECU 18.00	$17.75

[1]The twelve European Community member nations are Belgium, Denmark, France, the Federal Republic of Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, and the United Kingdom; prior to January 1986, Spain and Portugal were not members of the EEC.

[2]The only deliveries taken into account are those made to final users, namely the electric utilities or their procurement organizations; deliveries to middlemen or fuel cycle companies are not included. The sales between utilities in the Community are also excluded. The quantities covered are those which were entered into accounting records during the year stated.

[3]For deliveries made under medium or long-term contracts (i.e., for which the time between the date of signature and the date of the last delivery exceeds one year) the prices were expressed in seven different currencies. In order to calculate an average price, these prices have been converted into European Currency Units (ECU) and US dollars. The average prices were weighted by quantity and converted on the basis of the average annual exchange rate of the different currencies against the ECU and US dollar.

[4]Exchange rates are published by European Communities Statistical Office and the International Monetary Fund.

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GOVERNMENT STATISTICS

AUSTRALIA

		Consumer Price Index[1] (1980/1981 = 100)	Price Index of Materials Used in Manufacturing Industry — All Groups[2] (1984/1985 = 100)	Award Rates of Pay Indexes Australia - Adult Males In Mining Wage Earners, Weekly Rates[3] (June 1976=100)
1975	Avg.[4]	57.9	36.3	82.1
1976	Avg.	65.7	40.7	99.7
1977	Avg.	73.8	46.3	110.8
1978	Avg.	79.7	52.0	117.7
1979	Avg.	86.9	69.5	127.9
1980	Avg.	95.8	83.1	140.8
1981	Avg.	105.0	85.9	154.1
1982	Avg.	116.7	89.0	174.9
1983	Avg.	128.5	96.9	181.9
1984	Avg.	133.6	98.0	194.4
1985	Avg.	142.6	107.3	202.7
1986	Avg.	155.5	101.5	213.0
1987	Avg.	168.7	108.9	—
Jan	1987	—	106.2	215.9
Feb	1987	—	108.9	216.5
Mar	1987	164.7	108.4	222.2
Apr	1987	—	108.3	222.2
May	1987	—	108.1	222.0
June	1987	167.2	108.1	222.2R
July	1987	—	108.7	222.5R
Aug	1987	—	110.5	222.2R
Sep	1987	170.0	109.3	222.8R
Oct	1987	—	108.6	223.0
Nov	1987	—	110.0	222.6
Dec	1987	172.9	111.9	—
Jan	1988	—	112.4	—
Feb	1988	—	112.3	—
Mar	1988	176.0	112.3	—

P = Preliminary R = Revised since last month

[1]Weighted average of six State capital cities (1975 to 1980), and eight capital cities from 1981 (Base: Financial year July 1980 to June 1981 =100.0). Figures shown at end of quarter represent quarterly average.

[2]Australian Bureau of Statistics, Canberra: "Price Index of Materials Used in Manufacturing Industry" (Catalogue No. 6411.0).

[3]Australian Bureau of Statistics, Canberra: "Award Rates of Pay Indexes, Australia" (Catalogue No. 6312.0). Figures for the latest fourteen months shown are subject to revision.

[4]Monthly data for the period 1967 to 1986 appear in Report 233.

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CANADA

		Industrial Products Price Index: All Commodities[1] (1981 = 100)	Consumer Price Index: All Items (1981 = 100)	Wage-earner Data: Average Hourly Earnings (C$)[2] Uranium Mines (SIC 057)	Metal Mines (SIC 051-059)	Mines, Quarries and Oil Wells[3] (SIC 051-099)	Metal Rolling, Casting and Extruding (SIC 298)	Chemicals and Chemical Products Industries (SIC 372-379)
1979	Avg.	80.0	80.7	—	—	—	—	—
1980	Avg.	90.7	88.9	—	—	—	—	—
1981	Avg.	100.0	100.0	—	—	—	—	—
1982	Avg.	106.7	110.8	—	—	—	—	—
1983	Avg.	110.4	117.2	17.22	—	14.18	10.67	11.10
1984	Avg.	115.4	122.3	17.89	—	14.97	11.11	11.68
1985	Avg.	118.6	127.2	18.53	16.48	15.56	11.85	12.12
1986	Avg.	119.6	132.4	19.38	16.70	15.76	12.28	12.58
Jan	1987	120.0	135.2	19.53	16.93	16.03	12.58	12.89
Feb	1987	119.8	135.8	20.33	17.20	16.21	12.66	13.11
Mar	1986	120.4	136.4	20.04	17.14	16.15	12.58	13.02
Apr	1987	121.2	137.0	20.47	17.38	16.26	11.99	13.27
May	1987	122.0	137.8	20.50	17.12	15.96	11.44	13.19
June	1987	122.5	138.2	20.23	16.94	15.70	12.77	12.88
July	1987	123.2	139.2	19.75	16.73	15.63	12.52	12.98
Aug	1987	123.8	139.3	19.64	16.98	15.87	12.65	13.03
Sep	1987	124.1	139.3	19.85	17.20	16.25	12.57	13.40
Oct	1987	124.5	139.8	20.06	17.31	16.33	13.01	13.37
Nov	1987	125.1	140.4	20.47	17.50	16.50	12.63	13.53
Dec	1987	125.5	140.5	20.62	17.31	16.37	12.54	13.75
Jan	1988	126.4R	140.8	20.70	17.54	16.65	12.82	13.73
Feb	1988	125.8R	141.3	20.94	17.97	17.07	13.01	13.69
Mar	1988	126.1R	142.0	20.55R	17.88R	16.78R	13.10R	13.62R
Apr	1988	126.7R	142.5	21.03	18.21P	16.96P	13.29P	13.62P
May	1988	126.9	143.4	—	—	—	—	—

P = Preliminary R = Revised since last month

[1]Statistics Canada, Prices Division, Ottawa: "Industry Price Indexes" (Catalogue 62-011). Indexes for the most recent six months shown are subject to revision. This category was formerly known as "Manufacturing." Monthly data for the period 1967 to 1986 is found in Report 233.

[2]Statistics Canada, Labour Division, Employment and Payrolls Section, Ottawa: "Employment, Earnings and Hours." Monthly data for the period 1983 to 1986 is found in Report 233.

[3]Reports 175 through 185 list this series title incorrectly as "Metal Mining, Including Milling (SIC 050-099)."

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GOVERNMENT STATISTICS

REPUBLIC OF SOUTH AFRICA

		Average Declared Working Costs per Metric Ton of Gold Ore Milled (Rand)[1]	Tonnage-Weighted Index of Average Working Costs per Metric Ton of Gold Ore Milled (March 1982 = 100)[2]	Consumer Price Index[3] (1985 = 100)	Production Price Index All Groups[4] (1980 = 100)	Total Employment in Mining and Quarrying[5]	Total Salaries and Wages in Mining and Quarrying (1,000 Rand)[5]
1975	Avg.	16.71	—	29.4	52.1	639,473	1,003,217
1976	Avg.	19.30	—	32.7	59.9	671,240	1,212,983
1977	Avg.	23.87	—	36.3	67.7	712,006	1,420,670
1978	Avg.	27.14	—	40.3	74.3	658,261	1,502,975
1979	Avg.	30.18	—	45.6	85.6	686,599	1,795,638
1980	Avg.	35.53	—	51.9	100.0	709,042	2,237,689
1981	Avg.	41.89	—	59.8	113.6	722,918	2,756,928
1982	Avg.	47.25	104.2	68.6	129.4	702,041	3,181,584
1983	Avg.	51.88	115.0	77.1	143.1	700,901	3,563,282
1984	Avg.	58.95	130.3	86.0	155.1	711,511	4,134,390
1985	Avg.	68.76	151.6	100.0	181.2	724,587	4,778,612
1986	Avg.	80.22	177.9	118.6	216.6	756,637	5,767,950
1987	Avg.	—	—	137.7	246.8	750,256	—
Jan	1987	—	—	128.9	233.9	750,496	529,682
Feb	1987	—	—	130.3	237.0	758,230	600,258
Mar	1987	88.17	197.1	132.4	239.6	763,003	536,033
Apr	1987	—	—	134.1	242.5	765,309	535,876
May	1987	—	—	135.6	243.6	761,026	531,732
Jun	1987	90.74	203.5	136.6	244.9	763,319	571,407
July	1987	—	—	138.2	246.8	764,810	624,954
Aug	1987	—	—	140.2	249.9	761,338	564,387
Sep	1987	100.79	224.7	142.0	252.4	742,417	587,707
Oct	1987	—	—	143.6	255.5	725,599	599,116
Nov	1987	—	—	144.8	256.3R	734,630	616,725
Dec	1987	100.34	267.0	145.9	258.3	712,896	613,262
Jan	1988	—	—	147.2	261.5	711,983	615,889
Feb	1988	—	—	148.2	265.7	730,313	619,159
Mar	1988	102.96	232.4	150.2	268.4	—	—
Apr	1988	—	—	151.9	272.7	—	—
May	1988	—	—	153.1	—	—	—

P = Preliminary R = Revised since last month

[1]Chamber of Mines of South Africa, Johannesburg: "Analysis of Working Results," published quarterly. Historical Data by month appears in Report 236.

[2]Page 16 of Report 178 contains description and calculation of index, and page 24 of Report 178 lists figures for 1982.

[3]Central Statistical Service, Pretoria: All income groups-weighted average, Historical Data by month appears in Report 236.

[4]Central Statistical Service, Pretoria: All commodities for consumption in South Africa.

[5]Central Statistical Service, Pretoria: Historical Data by month appears in Report 236.

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UNITED STATES

		Producer Price Index[1]		Consumer Price	GNP Implicit Price	Gross Average Hourly Earnings of Production or Non-supervisory Workers (US$)[4]			
		Industrial Commodities (1982 = 100)	All Commodities (1982 = 100)	Index[2] (1982-1984 = 100)	Deflator[3] (1982 = 100)	Metal Mining (SIC 10)	Primary Non-ferrous Metals (SIC 333)	Chemicals and Allied Products (SIC 28)	Electric and Electronic Equipment (SIC 36)
1980	Avg.	88.0	89.8	82.4	85.7	10.26	10.63	8.30	6.94
1981	Avg.	97.4	98.0	90.9	94.0	11.55	11.98	9.12	7.62
1982	Avg.	100.0	100.0	96.5	100.0	12.31	12.93	9.96	8.21
1983	Avg.	101.1	101.3	99.6	103.9	12.58	13.43	10.58	8.67
1984	Avg.	103.3	103.7	103.9	107.7	13.05	13.43	11.07	9.04
1985	Avg.	103.7	103.2	107.6	111.2	13.38	13.74	11.56	9.46
1986	Avg.	100.0	100.2	109.6	114.1	13.20	13.49	11.98	9.65
1987	Avg.	102.6	102.8	113.6	—	—	—	—	—
Jan	1987	100.4	100.5	111.2	—	12.94	12.98	12.18	9.84
Feb	1987	100.8	101.0	111.6	—	12.99	12.83	12.21	9.84
Mar	1987	101.1	101.2	112.1	116.1	13.04	12.79	12.24	9.84
Apr	1987	101.6	101.9	112.7	—	13.16	12.90	12.30	9.82
May	1987	101.9	102.6	113.1	—	12.97	12.92	12.31	9.83
Jun	1987	102.4	103.0	113.5	117.2	13.05	12.93	12.27	9.84
Jul	1987	103.1	103.5	113.8	—	13.06	13.07	12.37	9.89
Aug	1987	103.7	103.8	114.4	—	13.03	13.07	12.34	9.90
Sep	1987	103.5	103.7	115.0	117.8	13.19	13.44	12.56	9.98
Oct	1987	104.0	104.1	115.3	—	12.96	13.06	12.52	9.95
Nov	1987	104.2	104.2	115.4	—	12.89	13.10	12.56	10.00
Dec	1987	104.1	104.1	115.4	118.7	12.78	13.14	12.62	10.05
Jan	1988	104.3	104.5	115.7	—	13.02	13.00	12.56	10.03
Feb	1988	104.4	104.6	116.0	—	13.13	12.93	12.55	10.04
Mar	1988	104.7	104.9	116.5	119.4	13.14	13.15	12.55	10.05
Apr	1988	105.6	105.8	117.1	—	—	—	12.52	10.10
May	1988	106.1	106.5	117.5	—	—	—	—	—

P = Preliminary R = Revised since last month

[1]US Bureau of Labor Statistics, Washington, D.C.: "Producer Prices and Price Indexes," (formerly "Wholesale Prices and Price Indexes"). Producer Price Indexes are revised four months after they are first released to reflect the availability of late reports and corrections by respondents. Historical data is presented in Report 233.

[2]US Bureau of Labor Statistics, Washington, D.C.: Consumer Price Index for All Urban Consumers, US City Average, All Items. Historical data is presented in Report 233.

[3]US Department of Commerce, Washington, D.C.: Bureau of Economic Analysis, National Income and Wealth Division: "Survey of Current Business." The GNP Implicit Price Deflator is published quarterly, and seasonally adjusted. Historical data is presented in Report 233.

[4]US Bureau of Labor Statistics, Washington, D.C.: "Employment and Earnings." All data based on 1972 revision of SIC Manual. Historical data is presented in Report 233.

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SERVICE LOCATIONS

DENVER, COLORADO, USA
Three Park Central
1515 Arapahoe Street
Suite 900
Denver, Colorado 80202
Telephone: (303) 893-4015
Telecopy: (303) 825-4821
Telex: 450202 (NUEXCO DVR)

SAN FRANCISCO, CALIFORNIA, USA
Building 1, Suite 105
3000 Sand Hill Road
Menlo Park, California 94025
Telephone: (415) 854-1510
Telecopy: (415) 854-2115
Telex: 470674 (NUEXCO)

TOKYO, JAPAN
Ohkura Building
1-4-10 Shiba Daimon
Minato-ku, Tokyo, Japan
Telephone: (81-3) 431-6025
Telecopy: (81-3) 434-6674
Telex: 242-5060 (JATECH J)

GENEVA, SWITZERLAND
13 chemin du Levant
01210 Ferney-Voltaire
France
Telephone: (33-50) 428035
Telecopy: (33-50) 428526
Telex: 385288 (NUEXCO F)

ZURICH, SWITZERLAND
135 Zurichstrasse
CH-8700 Küsnacht
Switzerland
Telephone: (41-01) 910-8977
Telecopy: (41-01) 910-6672
Telex: 58877 (NUXCH)

HONG KONG
1403 Shui On Centre
6-8 Harbour Road, Wanchai
Hong Kong
Telephone: (852-5) 865-1418
Telecopy: (852-5) 865-2721
Telex: 67206 (CNITC)

WASHINGTON, D.C., USA
2603 Valley Drive
Alexandria, Virginia 22302
Telephone: (703) 549-0880
Telecopy: (703) 549-0882

19636 Club House Road, Suite 110
Montgomery Village, Maryland 20879
Telephone: (301) 670-8660
Telecopy: (301) 670-8668
Telex: 248253 (SWUCO UR)

REPRESENTATIVES

AUSTRALIA **James G. Munro**
7 Nevada Street
North Balwyn, Victoria 3104
Australia
Telephone: (61-3) 857-6823
Telecopy: (61-3) 857-8258

SOUTH AFRICA **Chris I. von Christierson**
Southern Prospecting (Pty) Limited

Mailing Address
Post Office Box 61409
Marshalltown 2107
Republic of South Africa

Telephone: (27-11) 838-1868
(27-11) 834-4211

Street Address
10th Floor
Eagle Star House
70 Fox Street
Johannesburg 2001
Telecopy: (27-11) 834-3148
Telex: 4-89878-SA

UNITED STATES **Harold C. Lindberg**
83-A Hardee Lane
Whispering Pines, North Carolina 28327
Telephone: (919) 949-3622

JAPAN **Kazuo Yokota**
Japan Tech Services
Ohkura Building (3F)
1-4-10 Shiba Daimon
Minato-ku, Tokyo, Japan
Telephone: (81-3) 431-6031, 6025
Telecopy: (81-3) 434-6674
Telex: 242-5060 (JATECH J)

TAIWAN **Edward Bee**
Bee & Liang Company, Ltd.
14 FL Universal Business Center
NO. 663, Tun Hwa South Road
Post Office Box 1396
Taipei, Taiwan R.O.C.
Telephone: (886-2) 704-9630
Telecopy: (886-2) 703-4625
TWX 785-11570 (BEELIANG)

UNITED STATES **Ralph O. Smith**
141 Braemar Drive
Cheshire, Connecticut 06410
Telephone: (203) 272-6246
Telecopy: (203) 271-1346

INTERNATIONAL HEADQUARTERS

Three Park Central, Suite 900
1515 Arapahoe Street
Denver, Colorado 80202

Telephone: (303) 893-4015
Telecopy: (303) 825-4821
Telex: 450202/NUEXCO DVR